AFS SEPTEMBER, 1959

modern castings

COULD YOUR FOUNDRY HAVE USED

$600,000 MORE PROFIT IN THE LAST SIX YEARS . . .

WOULD YOU LIKE TO HAVE ALL YOUR EMPLOYEES SEARCHING

SYSTEMATICALLY FOR WAYS TO REDUCE COST . . . AND

EVALUATING THEIR OWN JOB EFFICIENCY . . .

Work Smarter . . . Not Harder . . . p 36

ATTENTION FOUNDRYMEN . . . ARE YOU PLANNING TO

BUY A FORK LIFT TRUCK . . . DON'T PURCHASE UNTIL

YOU'VE READ W. A. MEDDICK'S ARTICLE IN MODERN CASTINGS . . .

How to Select a Fork-Lift Truck . . . p 40

THE EIMCO CORP. DEVELOPS . . .

New Steel Alloy . . . p 43

YES . . . HIGH SPEED MELTING IS HERE . . .

MELT 600-POUND HEATS OF IRON IN 25 MINUTES . . .

ONLY 7 MINUTES NEEDED TO MELT DOWN 200 POUNDS OF BRASS . . .

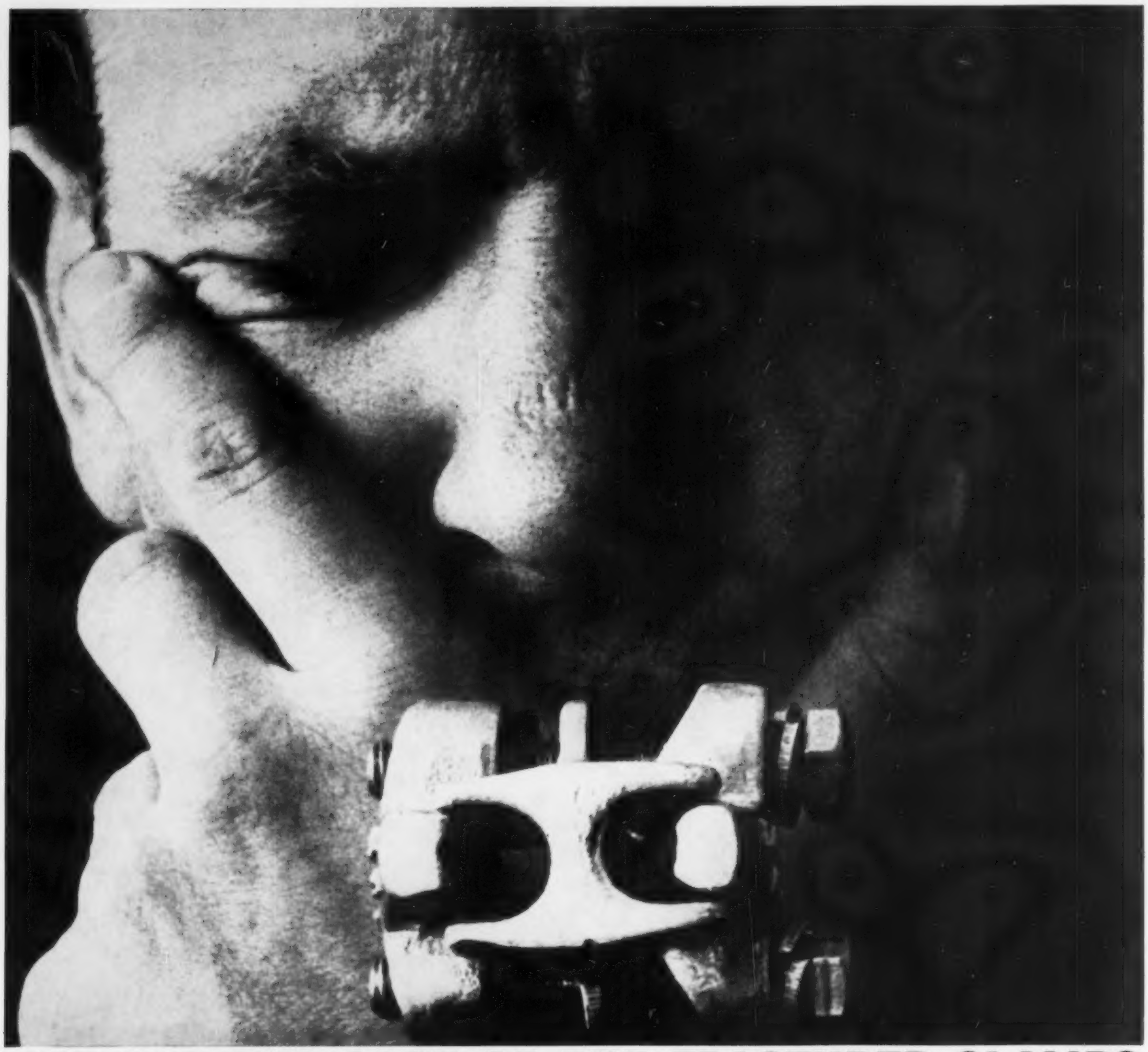
High Speed Melting . . . p 44

SHELL MOLDING IS HERE TO STAY . . .

BUT WATCH OUT FOR PRODUCTION PITFALLS . . .

HERE ARE SOME ELEMENTARY DO'S AND DONT'S . . .

Primer on Shell Molding . . . p 48



THE CURIOUS CASE OF THE FRACTURED CLAMPS

Another costly mystery solved–by the man from Kaiser Aluminum

THE PUZZLING FACTS. A customer of Kaiser Aluminum had been manufacturing an electrical connector clamp from a casting of primary standard 356 aluminum alloy. But–he often experienced difficulties due to cracking and breakage in use. What to do?

HOW THE CASE WAS SOLVED. After an on-the-scene check, the man from Kaiser Aluminum came up with the answer. His recommendation: use Kaiser Aluminum alloy A-356, a *high purity* alloy specially developed to provide greater ductility and strength in just such castings as these. Result: a superior clamp that developed a reputation of reliability for the manufacturer–and much additional business.

WE LOVE A MYSTERY. This is one of many actual cases solved by Kaiser Aluminum working with a customer. Perhaps *you* have a mystery one of our technical engineers might help solve? He's ready to give you expert advice on any casting problem–including mold and die design, alloy selection, heat treatment, finishing, fluxing, metal transfer.

FULL ALLOY AVAILABILITIES. Kaiser Aluminum can supply you *fast* with a wide selection of casting alloys to suit any engineering requirement–from general purpose, low stressed alloys to alloys having good properties at elevated temperatures.

FOR PIG AND INGOT with a free sleuthing bonus, call your nearest Kaiser Aluminum sales office now. Or write to: Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

See "MAVERICK" • Sunday Evenings, ABC-TV Network • Consult your local TV listing.

Circle No. 145, Page 157-158

september, 1959
vol. 36, no. 3

modern castings

the technical magazine of the metalcasting industry

features

1959 Castings Congress Papers

departments

featurettes

future meetings and exhibits

SEPTEMBER

15-17 . . American Die Casting Institute, *Annual Meeting*. Edgewater Beach Hotel, Chicago.

18 . . Malleable Founders Society, *Industry Meeting*. Hotel Sheraton-Cleveland, Cleveland.

21-22 . . Steel Founders' Society of America, *Fall Meeting*. The Homestead, Hot Springs, Va.

23 . . American Management Association, *Annual Meeting*. Hotel Astor, New York.

24-26 . . *AFS Missouri Valley Regional Foundry Conference*. University of Missouri, School of Mines & Metallurgy, Rolla, Mo.

28-Oct. 1 . . Association of Iron and Steel Engineers, *Annual Convention*. Sherman Hotel, Chicago.

28-Oct. 1 . . American Welding Society, *Fall Meeting*. Hotel Sheraton-Cadillac, Detroit.

29-Oct. 1 . . National Association of Corrosion Engineers, *Western Regional Conference*. Bakersfield Inn, Bakersfield, Calif.

OCTOBER

1-2 . . AFS *Empire State Regional Foundry Conference*. Drumlins Country Club, Syracuse, N. Y.

2-3 . . AFS *Northwest Regional Foundry Conference*. Benjamin Franklin Hotel, Seattle.

3-10 . . International Committee of Foundry Technical Associations, *International Foundry Congress*. Madrid, Spain.

7-9 . . Gray Iron Founders' Society, *Annual Meeting*. Fairmont Hotel, San Francisco.

8-9 . . AFS *Michigan Regional Foundry Conference*. Pantlind Hotel, Grand Rapids, Mich.

11-16 . . American Society for Testing Materials, *Pacific Area National Meeting & Exhibit*. Sheraton Palace Hotel, San Francisco.

15-17 . . Foundry Equipment Manufacturers Assn., *Annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

16-17 . . AFS *New England Regional Foundry Conference*. Massachusetts Institute of Technology, Cambridge, Mass.

19-23 . . National Management Association, *Annual Meeting and National Conference*. Statler-Hilton Hotel, Detroit.

19-23 . . National Safety Council, *National Safety Congress & Exposition*. Conrad Hilton Hotel, Chicago.

21 . . Cast Bronze Bearing Institute, *Annual Meeting*. Bedford Springs Hotel, Bedford, Pa.

22-23 . . AFS *Ohio Regional Foundry Conference*. Deshler-Hilton Hotel, Columbus, Ohio.

22-24 . . Non-Ferrous Founders' Society, *Annual Meeting*. Bedford Springs Hotel, Bedford, Pa.

29-30 . . AFS *Purdue Metals Casting Conference*. Purdue University, West Lafayette, Ind.

NOVEMBER

6-7 . . National Foundry Association, *Annual Meeting*. Roosevelt Hotel, New York.

9-11 . . Steel Founders' Society of America, *Technical & Operating Conference*. Carter Hotel, Cleveland.

20-21 . . AFS *East Coast Regional Foundry Conference*. Statler-Hilton Hotel, New York.

DECEMBER

2-4 . . Metallurgical Society of American Institute of Mining, Metallurgical & Petroleum Engineers, *Electric Furnace Conference*. Cleveland Hotel, Cleveland.

13-16 . . Material Handling Institute, *Annual Meeting*. Savoy-Hilton Hotel, New York.

2-4 . . National Association of Manufacturers, *Annual Meeting*. Waldorf-Astoria Hotel, New York.

1960

MAY

9-13 . . AFS 64*th Annual Castings Congress & Foundry Show*. Convention Hall, Philadelphia.

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THOUSANDS OF Carver RAPID MULLERS NOW IN USE

The most POPULAR, most PRACTICAL muller on the market . . . Here's why . . .

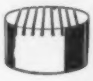
- The fastest! A batch every 75 seconds!
- Absolutely *no* lumps or wet spots!
- Easiest to clean! Just reach inside
- Only *one* moving part . . . no maintenance worries!
- 3 times lower initial investment than with most mullers!
- Works equally well with *any* kind of binder!

IF YOU COMPARE MULLERS CAREFULLY . . . YOU'LL CHOOSE CARVER

Only **Carver** *Has Everything For the* CO_2 *Process!*

CARVER V & S
Core Shooters

CARVER
Automatic Gassing Apparatus



KRAUSS
Taper Slot Core Vents

STEINEX

STEINEX
available only from CARVER

MAIL COUPON TODAY

CARVER FOUNDRY PRODUCTS CO.
Muscatine, Iowa

I want to compare! Tell me more about Carver Rapid Muller.

NAME ______________________ TITLE ____________

FOUNDRY ______________________________________

CITY ______________________ STATE ____________

Circle No. 146, Page 157-158

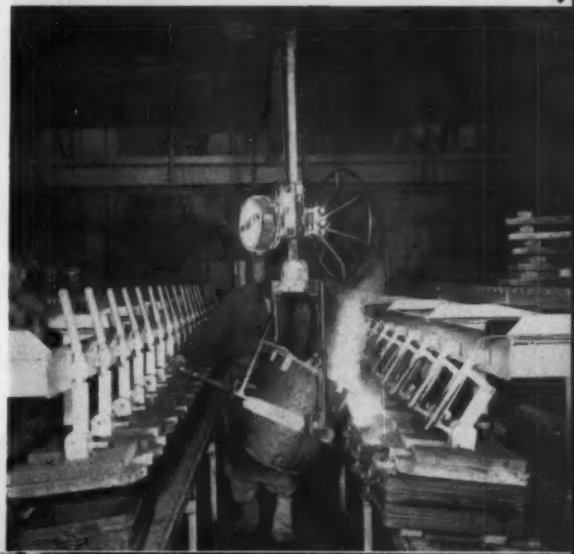
NONFERROUS TONNAGES

poured the MODERN *ONE-MAN* way!

Wherever metal is tapped, distributed and poured — MECHANICALLY — the chances are good that the pouring equipment is MODERN! Working together with practical foundrymen our highly experienced MODERN engineers built the first pouring machine for pouring hot metal. That was more than thirty-five years ago. All down through the years, and under the protection of a score or more patented improvements, the MODERN pouring equipment has led the way to synchronized timing in the handling of molten metal — cleaner metal and hotter metal!

Whether your nonferrous metal is melted in crucibles in their pit furnaces or in tilting gas fired and electric furnaces there's a one-best, ***ONE-MAN*** system available for your use. MODERN engineers welcome the opportunity to plan along with you.

Number 100, 330 lb. capacity crucible is hoisted by tongs from the pit furnace and lowered into position in the shank ring on crucible-holding stand at Lincoln Brass Works, Detroit. Detachable bail on the MODERN "F" type Pouring Device lifts the shank, crucible and molten brass for *ONE-MAN* pouring on conveyor line.



MODERN

MODERN EQUIPMENT COMPANY
Port Washington, Wisconsin

Type "F" MODERN Pouring Device with 17½" tapered ladle (specially lined) receives 350 lbs. of brass at gas fired, tilting furnaces at Milwaukee Faucets, Inc. *ONE-MAN* pouring is completed on MODERN half-ton, trolley type crane.

the editor's report

by Jack Schaum

■ **New molten metal filtering process** removes gasses and inclusions just before metal enters mold cavity. Suited to all metals . . . the highly porous filter is made from silica, resins and additives. Read U. S. Patent No. 2788554 for all the details.

■ **Highlights from The Material Handling Institute's Exhibition of '59** . . . completely radio controlled fork lift truck for handling radioactive materials in contaminated areas . . . Vacuumized power sweeper capable of picking up soft drink bottles, pieces of 2 x 4's, chunks of steel plate, metal turnings, milk bottles and even dust . . . Vacuum cup lift truck attachment which permits handling of cartoned material without need for clamps or forks . . . Four-wheeled self propelled hydraulic crane which can lift 10 tons, extend horizontally 25 ft, swing through full circles and tilt upwards 60 degrees.

■ **Don't be half safe** . . . put thermocouples in your large cores if you are at all concerned about the progress of your core baking cycle. Cooper Alloy Corp., Hillside, N.J., endorses this practice for better core quality.

■ **New Safety Record claimed!** Several months ago we asked in this column if any plant could top the 4693-day record of no lost time accidents established by the pattern shop of Texas Foundries, Inc. We promptly heard from J. A. Penney, Foreman, Pattern Shop, Crane Ltd., Montreal, Que. By midnight, July 8, they had racked up 5797 consecutive working days without a lost time accident. This is just a few days short of 16 years! Makes you realize you're safer at work than at home. Let's hear from some more contenders.

■ **Induction melting** is another answer to the problem of how to use cast iron and steel chips. In areas where electricity is available at one cent per kilowatt and iron chips are valued at $20 per ton you can have molten iron ready for the mold at a cost of only $30 per ton. Melting losses range down around 2-5 per cent.

■ **"The Next Inspector is our Customer"** . . . that message is on display in the Inspection Dept., Central Foundry Div., GMC, Danville, Ill., where it appropriately reminds the workers of their daily responsibility to ship only the best.

■ **Nothing succeeds quite like success.** And success requires, for one thing, an atmosphere of positive action. In a talk by Frank Shipley, Caterpillar Tractor Co., he made a count down on negative attitudes that undermine the foundations of progress. According to Shipley, "If we are to succeed we must erase from our vocabulary such phrases as: We tried that before . . . It costs too much . . . We don't have time . . .We're too small for it . . . Not practical for operating people . . . We've never done it before . . . That's not our problem . . . Why change it, it's still working O.K. . . . You're two years ahead of your time . . . We're not ready for that . . . Top management would never go for it . . . Let's shelve it for the time being . . . Why hasn't someone else tried it . . . Too hard to sell . . . It won't work in our industry . . ." And so on and on it goes. You could all add to these familiar phrases more of the same that reflect negative thinking — the easy way out. **Faced with the choice of success or else . . . the best guarantee of survival lies in first modernizing your thinking.**

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Circle No. 147, Page 157-158

Circle No. 148, Page 157-158

Build an idea-file for improvement and profit. The post-free cards on *the last page* will bring more information on these new . . .

products and processes

CYLINDER DUST BOOT . . . plastic film dust boot protects operating rods of air and hydraulic cylinders. Minimum thickness allows installation on existing cylinder without limiting stroke. *A. F. Gagne, Associates.*
For More Information Circle No. 1, Page 157-158

PORTABLE GRINDER . . . pneumatic units are available in speeds of 9000, 7200, or 6000 rpm. Choice of three handle types. *Thomas C. Wilson, Inc.*
For More Information Circle No. 2, Page 157-158

BENCH VISE . . . features new, open-center construction and quick-change device. *Stroudsburg Engine Works, Inc.*
For More Information Circle No. 3, Page 157-158

TRUCK DUMPER . . . lifts and dumps complete inplant trucks into hoppers, bins or conveyors. Capacity to 3000 lb and 50 ft lift. *Conveyors and Dumpers, Inc.*
For More Information Circle No. 4, Page 157-158

MARKING PENCIL . . . all-purpose pencil of normal pencil size, writes on any surface. Not a paper-wrapped grease pencil, use pencil sharpener to make point. *J. S. Staedtler, Inc.*
For More Information Circle No. 5, Page 157-158

SAFETY GLOVES . . . a new line of four styles provide protection for welders. *Air Reduction Sales Co.*
For More Information Circle No. 6, Page 157-158

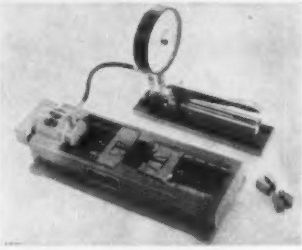
CHAIN ASSEMBLIES . . . accommodate electro-magnets of all sizes and lifting capacities. Many new safety features. *American Chain Div., American Chain & Cable Co.*
For More Information Circle No. 7, Page 157-158

GAS BURNER . . . for all drying and curing processes provides flexibility of temperatures and loads because of 25:1 throttling range. *Maxon Premix Burner Co.*
For More Information Circle No. 8, Page 157-158

PALLET BOXES . . . re-usable wooden pallet boxes may be assembled and disassembled repeatedly. *General Box Co.*
For More Information Circle No. 9, Page 157-158

TROLLEY HAND HOIST . . . save working space by reducing headroom to 50 per cent. *Yale & Towne Mfg. Co.*
For More Information Circle No. 10, Page 157-158

TENSILE TESTER . . . portable unit performs standard tensile and compression tests. Machines available in two



sizes: 5000 to 20,000 lb capacity or 20,000 to 40,000 lb capacity. *Steel City Testing Machines, Inc.*
For More Information Circle No. 11, Page 157-158

INVESTMENT MOLD FURNACE . . . gas-fired unit is specially designed for high firing shell investment molds. Furnace attains 160 F in 15-20 min. *Alexander Saunders & Co.*
For More Information Circle No. 12, Page 157-158

NON-WATER WASHES . . . zircon base Alco-Z and graphite base Alco-G core and mold washes are supplied ready for mixing with methyl or isopropyl alcohol. *Asbury Graphite Mills, Inc.*
For More Information Circle No. 13, Page 157-158

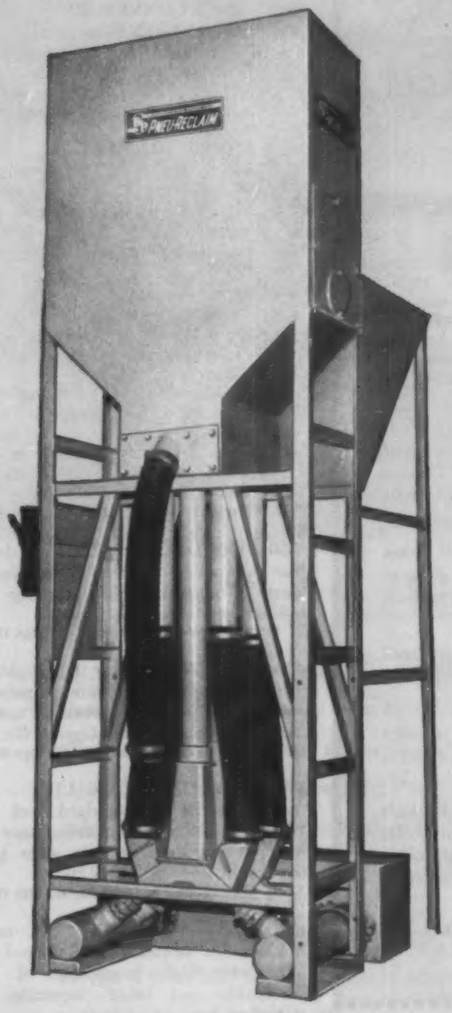
STEEL ADDITIVE . . . Graphidox is introduced as a proven supplementary deoxidizer for foundry steels. *Vanadium Corp. of America.*
For More Information Circle No. 14, Page 157-158

SAND ADDITIVE TRANSPORTER . . . meters and delivers dry materials such as fire clay, sea coal, or wood flour into sand mixer accurately and automatically. Pneumatically operated machine is designed for application where gravity feed cannot be used. *Harry W. Dietert Co.*
For More Information Circle No. 15, Page 157-158

SHELL BOND APPLICATOR . . . accurately places on the halves of shell mold resin used to bond halves together. Machine applies bonding resin with accuracy which permits cores to be set before applying resin. Units available

Continued on page 10

IS YOUR FOUNDRY DUMPING OVER $12,000 IN RECLAIMABLE SAND THIS YEAR?



EVEN SMALLER FOUNDRIES DO...

Large expenditures for new sand aren't limited to the larger foundries. Many foundrymen are surprised and even shocked when they calculate the cost of new sand in their foundry operations. One typical medium-size foundry revealed these figures:

Cost of new sand per ton at siding	$5.83
Cost of moving sand to storage, per ton	.65
Cost of storage, per ton	.25
Cost of trucking used sand to dump, per ton	.55
Total cost, per ton	$7.28
Total cost per month (based on 150 tons/month)	$1,092.00

Of course, bigger foundries spend more . . . much more. Yet, the sand hauled to the dump is perfectly reclaimable for use as new sand. The sand dumped represents dollars lost forever . . . dollars that a reclamation unit could save.

NOW—RECLAMATION COSTS LESS

The newest of dry reclamation units—Pneu-Reclaim—actually costs less to install and use than earlier units. Its many exclusive features—dual-jet scrubbing, high recovery fines control, level-flow and simple quantity-quality control—mean lower-cost operation and superior peformance. The typical costs shown below are based on hundreds of actual tests:

Typical cost of reclaiming for reuse in molding sand mixtures, per ton	30c
Typical cost of reclaiming for reuse in core sand mixtures, per ton	90c
Typical cost of reclaiming for reuse in CO_2 sand mixtures, per ton	60c

These costs include all of the charges for power, maintenance and operation. Because Pneu-Reclaim *requires half the air pressure for operation, it consumes half the power required by earlier units.*

AND SAVES MORE!

It's easy to find how much Pneu-Reclaim can save your foundry. Simply compute the actual cost of each ton of sand delivered to your foundry, used in your system and then discarded, and subtract the cost of reclamation. The difference represents the saving offered by Pneu-Reclaim per ton of sand reclaimed and used in lieu of new sand.

TYPICAL EXAMPLE

Cost per ton of sand delivered, used and discarded	$7.28
Cost per ton of sand reclaimed for reuse in molding sand mixtures	.30
Saving per ton	$6.98
Saving per month (based on 150 tons/month)	$1,047.00

A no-obligation demonstration will prove these facts for you. Write today!

B&P PNEU-RECLAIM

Beardsley & Piper
Div. Pettibone Mulliken Corp.
2424 N. Cicero Ave. • Chicago 39, Illinois

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products and processes

Continued from page 8

for 15 x 20 in. or 20 x 30 in. shells. *Shell Process, Inc.*
For More Information Circle No. 16, Page 157-158

PLUNGING LADLES . . . for use in new ductile iron technique comes complete with loose covers. Ladles available in eight capacities from 1000 to 6000 lb. *Industrial Equipment Co.*
For More Information Circle No. 17, Page 157-158

ZIRCON WASH . . . refractory coating for cold-setting cores and molds improves casting finish. Wash should be oven dried after application. *G. E. Smith, Inc.*
For More Information Circle No. 18, Page 157-158

RECESSED CONVEYORS . . . lend flexibility to jobbing shops or foundries pouring once a day. Molds are set on wheeled pallets which move on rails in floor. *Nomad Equipment Div., Westover Corp.*
For More Information Circle No. 19, Page 157-158

36-in. DISC SANDER . . . features safety, low maintenance, precision, and added disc area and clearance for hook-shaped work pieces. *Master Pattern Works, Inc.*
For More Information Circle No. 20, Page 157-158

NOISE KILLER . . . vinyl plastic and fiber glass machine mounting pads are said to eliminate 90 per cent of destructive vibrational tremors and noise. *Lowell Industries, Inc.*
For More Information Circle No. 21, Page 157-158

RELEASE AGENT . . . for zinc die castings is said not to dance or sputter on hot surfaces. Extendable with water or solvent. *American Charcoal Co.*
For More Information Circle No. 22, Page 157-158

450 TON DIE CASTER . . . designed for production of deep draw aluminum parts produces pieces weighing up to 16 lb. *Lester-Pheonix, Inc.*
For More Information Circle No. 23, Page 157-158

EAR PROTECTOR . . . lightweight protector provides optimum noise protection for personnel working near loud noises. *Bausch & Lomb Optical Co.*
For More Information Circle No. 24, Page 157-158

SIDE SADDLE FORK LIFT . . . attachment for all standard fork trucks allows use of narrower aisles since trucks do not need to turn in aisle to face stacks. *Equipment Mfg., Inc.*
For More Information Circle No. 25, Page 157-158

EXHAUST PURIFIER . . . catalytic muffler for in-plant tractors and trucks eliminates high percentage of carbon monoxide and other impurities. *Oxy-Catalyst, Inc.*
For More Information Circle No. 26, Page 157-158

RAMMING MIX . . . is recommended for lower sidewalls and bottoms of aluminum melting and holding furnaces. *Refractories Div., H. K. Porter Co.*
For More Information Circle No. 27, Page 157-158

METAL SORTER . . . transistorized

Continued on page 16

HAVE YOU GOT HANDLEBAR HARRY?

Enter National's $5000 Contest Search

If your Simpson Mixer was built before 1920, you may own *Handlebar Harry* . . . the oldest Mix-Muller still in foundry operation and a machine of great historical significance. National would like to locate this sturdy old-timer and reward you with a jet-propelled, hula-whooping trip to Hawaii for helping them!

All Simpson Users are Eligible to Enter

Even if your Mix-Muller is brand new, you will still be eligible to compete for 19 other prizes in the $5000 *Handlebar Harry Contest.*

Why HANDLEBAR HARRY?

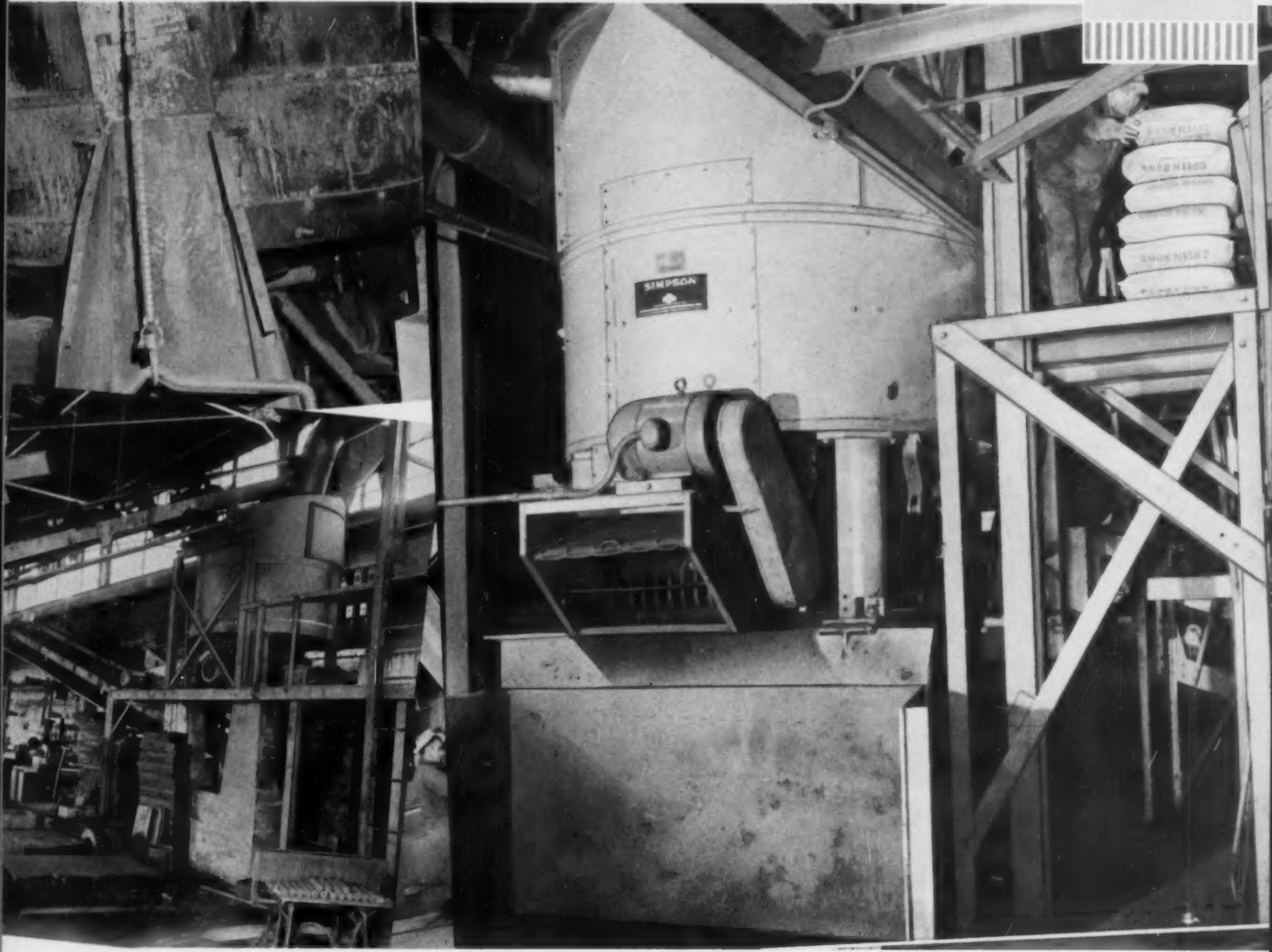
The purpose of the contest is to celebrate the inauguration of National's *Mix-Muller retirement plan* — a program designed to make it easier and more economical for Simpson users to *trade up* to a modern, high production F-Series Mix-Muller—*to meet the production challenge of the '60s.*

See following pages for details ———

SIMPSON MIX-MULLER

NATIONAL ENGINEERING COMPANY · Chicago 6, Illinois

If your Mix-Muller is over 20 years old... A MODERN F



COMPARISON TABLES between Model 2 Simpson built 1930

PERFORMANCE:

	1930 SIMPSON	MODEL F MIX-MULLER	
BATCH CAPACITY	1200 lbs. (max.)	2000 lbs. (min.)	67% more
OUTPUT PER HOUR (G.I. Mold.)	12 tons (max.)	24 tons (min.)	*100% more
DISCHARGE TIME	40 seconds	20 seconds	50% less
MULLING EFFICIENCY	On basis of time required to develop sand characteristics compatible with modern foundry practice overall 2F efficiency is about..		30% greater
EQUIPMENT COST (per ton/hr. of sand prepared)	Based on present day prices, the 2F Mix-Muller will turn out 100% more sand per hour at an equipment investment amounting to...		31% less cost per ton/hr.

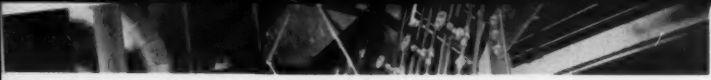
CONSTRUCTION:

	1930 SIMPSON	MODEL F MIX-MULLER
MULLER SUSPENSION	Rocker arms. 3 weights of mullers 700, 1000, 1600 lbs. Manual adjustment. Non-reversible.	Spring loaded—automatically adjusts to provide more pressure as sand increases in strength. Reversible.
DISCHARGE DOOR	Hand fitted. No adjustment for wear.	Machined to close tolerance and equipped for wear adjustment. Opening is 100% larger.
BEARINGS	Sleeve.	Anti-friction throughout.
DRIVE	Open bevel, direct connected.	V-belt, self-contained, splash lubricated reducer.

*Actual tonnage will vary widely depending upon many variables. However, percentage figure has been firmly established by performance tests.

SIMPSON MIX-MULLER

Trade up! Meet the Production Challenge of the 60's with ...



SERIES MIX-MULLER CAN GIVE YOU:

and Model 2F Mix-Muller built 1960

67% Greater Ba
100% More Prod
30% More Mulli

If your Simpson Mix-M
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for an F-Series Mix-Mu
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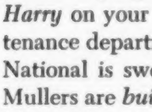
Mullers are *built* for mil
Mix-Muller is built to
challenge of the '60s, an
to assist you in meetin
the . . .

	SERVICE AND OPERATING: 1930 SIMPSON	MODEL F MIX-MULLER
LUBRICATION	5 alemite fittings.	"One stop" centralized system for all interior components.
PLOW ADJUST	Wrench and hammer, from inside crib.	From **top** of cross head.
OVERHAUL	Roll up sleeves.	Roll out mullers and/or turret assy. through removable crib section — without dismantling hoods, hoppers, etc.



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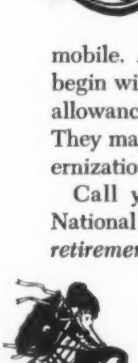


NA
ENG
CO
Chica

F Series MIX-MULLER

J:

r Batch Capacity
Production per hour
Mulling Efficiency

Mix-Muller is over 20 years use, you have *already paid* x-Muller—without receiving ncreased production, greater and lower maintenance.

chart outlines the basic fea- x-Mullers built before 1951 ce. It is designed to tell you

omparison between the pro- of the two machines.

nt salesman who offers you d on the performance of the r and his own 1960 Model straightforward with you.

Muller is described in the it was built before 1951, it . . yet it is a valuable asset 960 F-Series Mix-Muller.

ned obsolescence . . . it is If you've got *Handlebar* ipment payroll, your main- t is to be congratulated and g with pride because Mix- r mileage. But, the F-Series lt to meet the *production* 0s, and National is prepared eeting this challenge with

MIX-MULLER
RETIREMENT
PROGRAM

our Mix-Muller was built re 1951, you can now trade as you would your auto- s have been set up which alue and run up to a liberal price of a new Mix-Muller. recommendation for mod- y" is in good shape.
TIONAL agent or write r details on the *Mix-Muller*

NATIONAL
GINEERING
COMPANY
icago 6, Illinois

HANDLEBAR HARRY CONTEST

OFFICIAL ENTRY BLANK

Be sure to fill in the 50-word statement below.

1. I have read and agree to the contest rules. Here is my entry. The serial number of our *Handlebar Harry* is __________.

(If more than one mixer, enter oldest number only.) If no record of serial number, contact your National Agent.

2. This Simpson Mixer is in regular operation in our foundry and has been the property of our company for ____ years.

Your Name____________________

Your Company____________________

Address____________________

City________ Zone____ State________

Entry must be postmarked no later than midnight, February 28, 1960.

50-Word Statement

In 50 words or less, tell how this Simpson Mix-Muller has contributed to the success of your foundry operation: Example: **This Mix-Muller has served our foundry daily for ______ years without downtime for repairs. In that time, it has prepared ______ tons of sand.**

(type or print below . . . or attach a separate sheet)

M

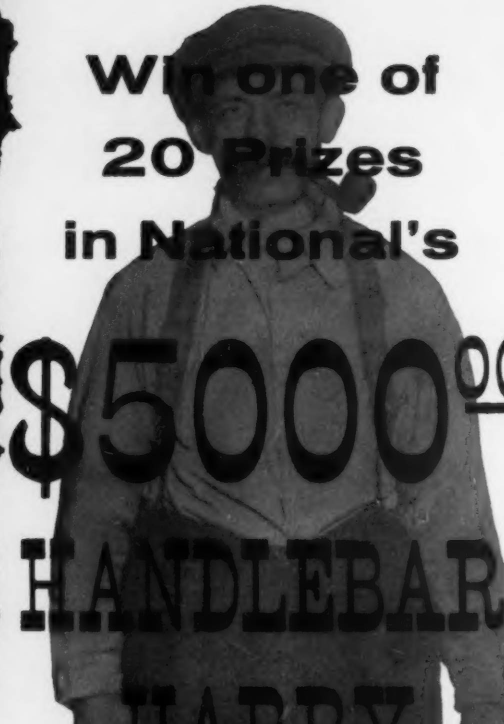
F

DM

TEAR OFF and return to:

HANDLEBAR HARRY
National Engineering Co.,
Machinery Hall, Chicago 6, Illinois

HAND



Win one of

20 Prizes

in National's

$5000.00

HANDLEBAR

HARRY

CONTEST

Don't delay! Return

your Entry today

See reverse side

for

Entry

Blank

FIRST GRA

(for Handlebar

Trip to Hawa
Airlines 707 J
Pan America
Ten dream da
at the luxuri
Hotel. Side t

CONTEST

Any Simpson Mix-Mulle
as entry is accompanie

1. Only foundrymen, person operation are eligible to e

2. Serial number of the mach If nameplate is missing, co

3. Your **Handlebar Harry** m and have been the prope one year.

4. More than one entry from only one prize will be awar

5. Ties will be settled upon originality and sincerity of statement. Judges have be

6. All entries must be accom No entries will be returned National Engineering Com

7. No cash prizes will be a chandise. In event first pri expected that winner com

8. Contest is limited to resi Canada. It is subject to all tions. Any federal, state will be sole responsibility

9. All entries must be postm February 28, 1960. Winners Convention in Philadelphia

NATIO

6

Circle No. 153, Page 157-158

products and processes

Continued from page 10

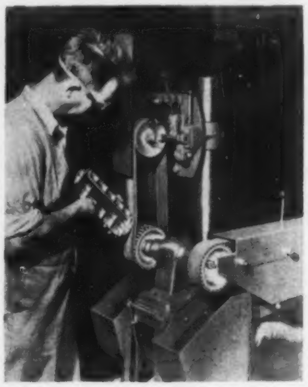
conductivity-permeability meter will locate pieces made of a given ferrous or non-ferrous metal in a mixed lot of parts or scrap. *Metrol, Inc.*
For More Information Circle No. 28, Page 157-158

FILTER BAGS . . . glass fiber bags are designed for baghouse dust and fume collection systems in high temperature applications. *Filter Div., Coast Mfg. & Supply Co.*
For More Information Circle No. 29, Page 157-158

CRANE SCALE . . . suitable for use under extreme conditions is available in capacities of 1000 to 20,000 lb. Pro-

ducer claims minimum size, reduced weight, maximum accuracy. *Martin-Decker Corp.*
For More Information Circle No. 30, Page 157-158

BELT GRINDERS . . new line of versatile, low-cost 2-1/2 in. abrasive belt



machines is available. *Walker-Turner Div., Rockwell Mfg. Co.*
For More Information Circle No. 31, Page 157-158

TRACTOR SHOVEL . . . 19 cu ft model is first in line of tractor shovels to be built by this manufacturer. Model L-7 has rear wheel steer, front wheel drive, 49 hp gasoline engine. *Euclid Div., General Motors Corp.*
For More Information Circle No. 32, Page 157-158

HEAVY DUTY CASTING TRUCK . . . is designed to receive castings on discharge from blast cleaning installation. *Sterling National Industries, Inc.*
For More Information Circle No. 33, Page 157-158

600-TON DIE CASTER . . . cold chamber machine designed for hand ladling, automatic ladling or automatic feeding. Produces aluminum die castings to 10 lb. *Reed-Prentice Div., Package Machinery Co.*
For More Information Circle No. 34, Page 157-158

TRACTOR-SHOVEL . . . with 5000 lb carry capacity features increased power, complete power-shift transmission, other refinements. New Model H-50 replaces Model HU Payloader. *Frank G. Hough Co.*
For More Information Circle No. 35, Page 157-158

EXHAUST HOOD . . for electric furnaces operates with reduced air volume and minimum interference with furnace operations. *Pangborn Corp.*
For More Information Circle No. 36, Page 157-158

SPRAY-ON PLASTIC . . sprayable high-density polyethylene coating which can be applied to metals and glass is now available. *Plastics Div., Koppers Co.*
For More Information Circle No. 37, Page 157-158

PLASTIC RUBBER . . new material for pattern and core box manufacture or repair has been developed. Resists abrasion and erosion. Suitable for other foundry applications. *Dike-O-Seal Inc.*
For More Information Circle No. 38, Page 157-158

SHELL CORE BOXES . . . are available cast-to-size by Shaw Process. Ledges on boxes permit use of inexpensive clamps. *Wisconsin Pattern Works.*
For More Information Circle No. 39, Page 157-158

CONTINUOUS CASTING . . . of aluminum strip is suggested as an auxiliary or side line operation for foundries. Newly developed integrated machine is said to produce 4 tons of 1/8-in. strip hourly. *Lobeck Casting Processes Inc.*
For More Information Circle No. 40, Page 157-158

DUCTILE IRON . . is produced more efficiently with alloy 55, a new high-magnesium silicon-base composition. Suitable for use in plunging technique. *Union Carbide Metals Co.*
For More Information Circle No. 41, Page 157-158

MULLER PLOWS . . for replacement service on Simpson machines increase service life 18 times; increase cost less than 4 times. Plow tip and other wearing surfaces are clad with tungsten carbide blocks. Circle the number below on the Reader Service Card, last page, for latest information about this product. *National Engineering Co.*
For More Information Circle No. 42, Page 157-158

how hot . . should a cupola be? Use the **Reader Service** card, last page, for mfg's. info on all types of equipment you use.

Announce Distribution of AFS Buyers Directory to Foundry Superintendents

■ Every foundry superintendent in the United States and Canada will receive a copy of the new AFS Buyers Directory free when it goes into the mails early in October, according to Curtis Fuller, Directory Manager. Larger foundries will receive additional copies.

The Directory is the first complete buyers' guide ever published to all the products, services, materials, and equipment bought by foundries; their trade and brand names; and the companies supplying them.

U.S. and Canadian foundry superintendents are not the only groups to receive free copies. Free distribution will also be made to U.S. and Canadian pattern shops and to Mexican foundries which are company members of AFS. In addition, the U.S. Government has arranged to place copies in the principal U.S. Foreign Service Libraries throughout the world.

Copies of the Directory will be sold at $10 each to regional and local distributors, national suppliers to the industry, pattern shops not members of AFS, foreign foundries and others. Total distribution of the Directory is planned to be approximately 11,000.

The Directory had originally been scheduled for distribution on September 15, but new sections added to it have delayed completion about two weeks, Fuller explained. Among the additions are a new section on foundry supply houses, plus more than 40 pages of information on all the foundry trade and technical associations which belong to the National Castings Council.

The market information sections of the Directory are all cross-indexed with each other for maximum use by foundry superintendents and purchasing executives. The advertising section; company listing section with names, addresses and telephone numbers; foundry supply house section, and the product listing section with more than 1,000 classifications and cross-reference classifications of products and services are all cross-indexed. Trade names are listed both alphabetically and by product classification in two separate sections.

The American Foundrymen's Society has been developing the AFS Buyers Directory for more than a year and a half, after a survey of key foundry executives showed the need for such a book. Previously, foundries have depended on general purchasing directories which are far less specialized.

German Molding Sand Technology

by Hans G. Hinrichs,
Industrial Agent,
Cohasset, Mass.

The 18th Foundry Conference at the Aachen Technological Institute in Germany discussed a new approach towards methods of qualitative analysis of clays and sands. Of interest was the attempt to define by scientific formula the true moldability of foundry sand.

A new tool for test and research is the analysis and determination of a clay's "specific surface area." Relative surface area becomes a visable, measurable quantity by adding methyl blue dye. A high value of specific surface area indicates a high quality clay. Permeability, green compression strength, hygroscopic properties, ion interchangibility and bond strength are all a direct function of the specific surface area of a mineral clay. Bentonite type clays have a specific surface area of 250-500 square meters per gram; kaolin type clays have a value of 50-150 square meters per gram.

Viscosity tests do not indicate the relative quality of bentonites. No conclusions should be drawn from such tests regarding their bond strength or thermal stability as binders in molding sands.

Colloid chemistry concepts serve to explain the influence of moisture content upon the green compression strength of molding sands. Green strength is lowered as moisture content rises beyond its optimum point of "true moldability".

Moisture requirements depend upon the ion arrangement in the space lattice of bentonites. Calcium bentonites require more moisture than sodium bentonites.

True Moldability

Despite its great importance, true moldability could heretofore only be determined subjectively, by hand test. But now, modern research has led to a test procedure that permits exact definition. Such tests are based on measuring green tensile strength in relation to the water contents of a sand mixture.

Originally, true moldability was identified with certain characteristics of a steam pressure curve taken from steam pressure readings on wet molding sands. Further tests indicated that this condition coincides with the peak of a green tensile strength curve plotted against the water content of the sand. Generally, this peak lies between maximum green compression strength and maximum permeability. However, progressive evaporation of moisture will cause the green tensile strength to drop off sharply while green compression strength continues to climb.

With a drop of only a few *decimals* of moisture percentage, a sand may lose practically all its green tensile strength while its green compression strength continues to read high. So the possibility and the extent of error is less if sands are tested for their green tensile strength rather than their green compression strength. For instance, test procedure for green compression strength may show too low a value if the sand has high plasticity, leading to a premature flow of the test sample. Plasticity does not influence the value for green tensile strength. For some time, Aachen Technological Institute has been testing for green tensile strength, rather than green compression strength.

Control of Defects

For positive control of such casting defects as scabs, buckles and rat tails, Aachen developed test instruments that quickly and easily check every one of the following factors against mold temperature: grain size, grain distribution, grain shape of the sand, moisture content and quantity, effective range of the clay bond.

Though corrective measures are identical with British-American foundry practice, i.e. by additions of seacoal, woodflour and organic binders, this test procedure emphasizes *adhesive strength* of sand mixes rather than the deformation factor.

As the mold face is heated by molten metal its moisture evaporates and percolates through the permeable mold material into the colder layers of the mold where it condenses. A zone of high moisture forms a few millimeters behind the mold face leaving a layer or "shell" of low moisture close to the mold-metal interface. Adhesive strength tests measure the green tensile strength of this "shell".

Castings defects were listed in their order of importance: scabs and rat tails, blowholes and porosity, rough surface and penetration. They are caused principally by lack of accurate moisture control and lack of control of permeability. Permeability of molding sands can often be regulated to a better degree by control of the adhesive strength of the clay than by changes in grain size and grain distribution of the basic sand.

Translated from Giesserei, April, 1959.

pouring off the heat

success story

■ Thank you for providing us with 200 reprints of the MODERN CASTINGS feature, "Forum for Designers and Buyers."

These were passed out to all attending the fourth session of the "1959 Engineered Castings Seminar," sponsored by the AFS Twin City Chapter. We considered this Seminar to be quite successful with the average attendance in excess of over 200 engineers, casting designers and buyers.

Frank S. Ryan, *Chairman*
Foundry Education Seminar
AFS Twin City Chapter

■ I certainly appreciate your comments about our Pattern Shop's safety record in the Editor's Report.

We are posting this on our bulletin board where the recognition will have a fine effect on the whole plant safety effort.

R. S. Bradshaw, Jr.
Texas Foundries, Inc.
Lufkin, Texas

gas war averted

■ The Bison Foundry in Huron has suggested that I write you. I am on the city Commission here in Huron. The City is very anxious to take all necessary precautions in the matter of zoning to prevent any adverse business from locating too near the foundry. In another city, the operator had the unfortunate experience of having a gas station built adjacent to his plant.

Can you tell us how far from the foundry it is safe to have gas storage?

MORGAN SANFORD
Huron, S.D.

There is no definite distance established for separating a cupola or other source of ignition from a gasoline station. Chicago allows gasoline stations adjacent to and in any industrial district with no separation limits from a source of ignition. I don't believe much risk is involved and Chicago's experience confirms this. With an inexpensive spark arrester installed on the cupola, there is scarcely any chance of ignited particles escaping and those that do will burn out in 50 ft.—H. J. Weber, Contributing Editor.

Circle No. 161, Page 157-158

Circle No. 162, Page 157-158

here's how

. . . **St. Louis Die Casting Corp.,** St. Louis, produces gear cases for Emerson Electric Co. with total toler-

ance including draft ±0.0005 in. The parts are die cast from zinc in 2-cavity die at 230 parts per hour.

. . . **Arrow Aluminum Castings Co.,** Cleveland, has taken wood core boxes previously used in green sand molding and converted them to the CO_2 process. If not already present, vents are located in strategic spots. The box is completely enclosed on four sides with boards and on bottom with plywood. An air valve is installed on the side. Thirty-three pounds of sodium silicate bonded sand are rammed into the box; a hose from

cylinder of CO_2 gas is attached to the entry valve on box; and presto, 45 seconds later the core is hardened. The gas has been introduced at the core surface where hardening is most critical. Any soft spots back in the center of the sand mass are of little consequence. Core is made on roll-over-draw machine to facilitate stripping. Finished core for truck transmission housing is visible in background.

. . . **T. B. Wood's Sons Co.,** Chambersburg, Pa., produces ductile iron cylinder heads for "Hoffman" laundry and dry-cleaning equipment. Head is riveted to stainless steel drum. Ductile casting replaces malleable part which tended to crack during annealing. Parts are either 36 in. or 42 in. diameter and 2 in. thick.

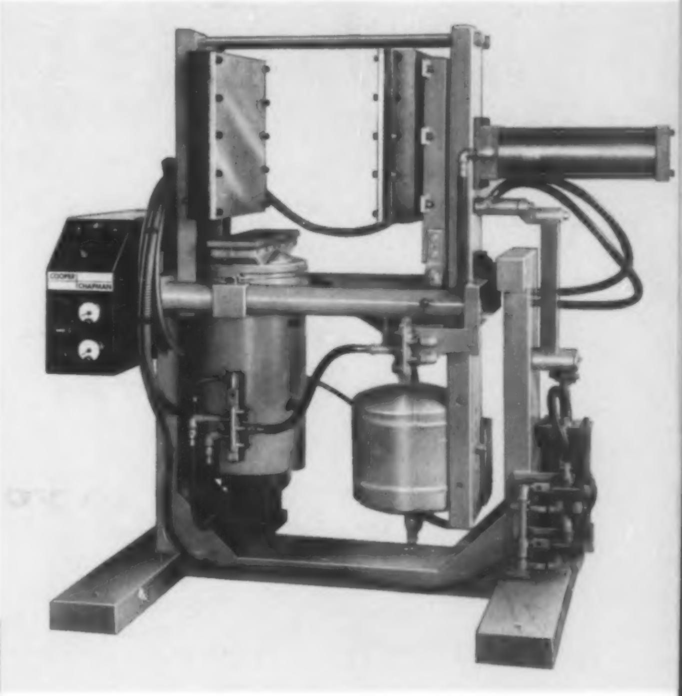
Circle No. 163, Page 157-158

TACCONE ULTIMATIC®

shell core blower

The finest, most economical
Shell Core Blower
available today

Field proven
for 2 full years



MODELS AVAILABLE

C-1615 — 7" maximum diameter core
C-1221 — 7" maximum diameter core
C-2021 — 9" maximum diameter core
C-1626 — 9" maximum diameter core
C-2415 — 9" maximum diameter core

Obtainable with semi-automatic or fully automatic pushbutton controls.

NOTE: *Model number designates maximum height and depth of box*

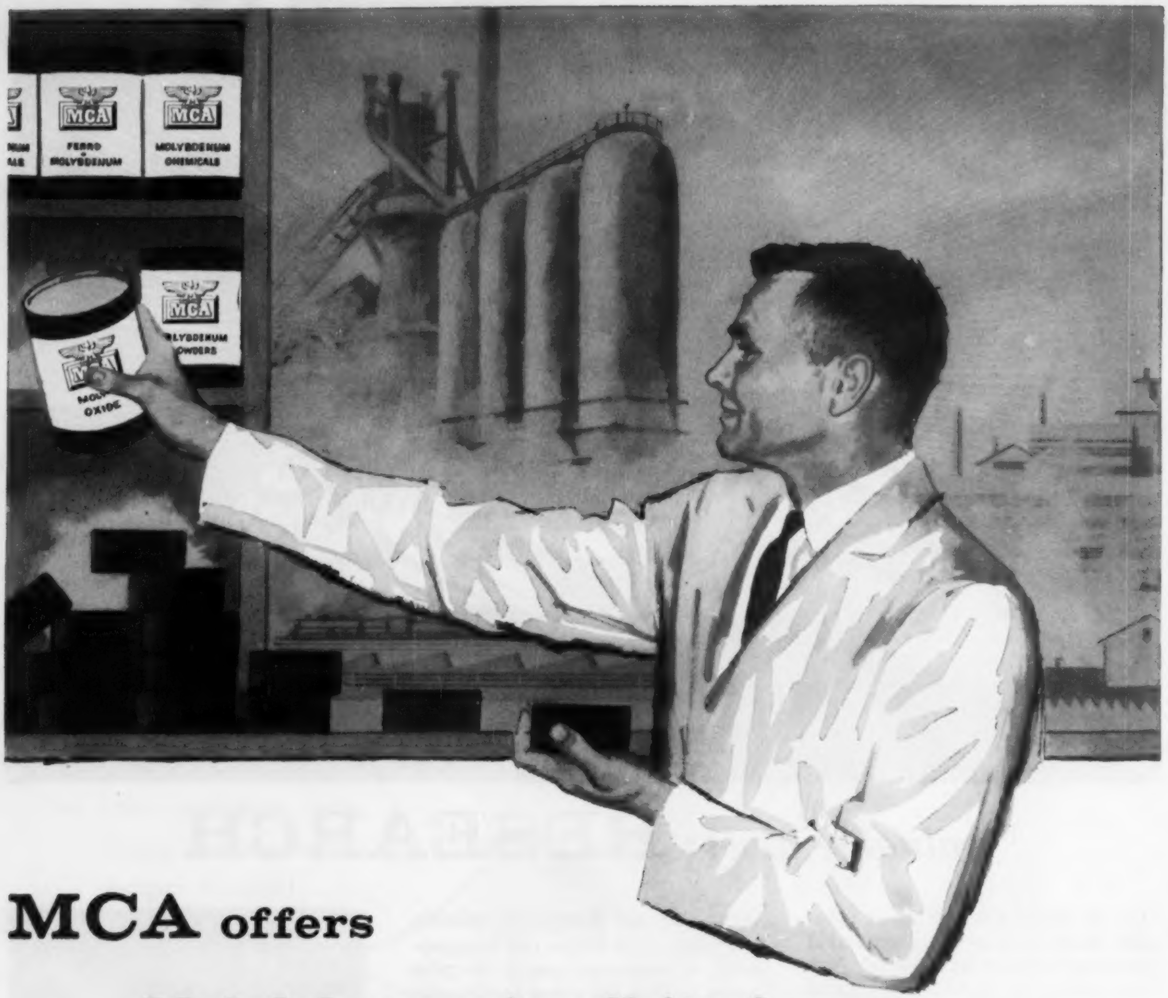
- High productive capacity
- Finished cores in 15 to 45 seconds
- Quick core box change
- Adjustable blow pressures
- Variable speed air cylinders on rotation
- 300 to 700° F. thermostatic control
- Curing starts immediately

1 operator

2 machines

International MINERALS CHEMICALS

over



MCA offers

Molybdenum in all its forms

Molybdenum is widely accepted in the iron and steel industry, because it imparts improvements in physical properties at costs that may be economically justified. Such properties are effective both in economy of production and user benefits. In high speed steels, automotive steels, in aircraft and missile steels, molybdenum by MCA performs to meet designer's requirements.

This expanding use of molybdenum has resulted in demand for various forms—chemicals, metal powder, metallic molybdenum and molybdenum oxide. MCA offers molybdenum in all commercial forms for easy and practical application in the mill. In addition, MCA's technical knowledge is unsurpassed and is available to the iron and steel maker upon request, free of charge.

When you have a metallurgy problem that molybdenum might solve, think first of MCA. When you need molybdenum in any form or quantity, MCA has it available for your use in iron and steel improvement.

MOLYBDENUM

2 Gateway Center CORPORATION OF AMERICA Pittsburgh 22, Pa.

MCA

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco
Sales Representatives: Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.

Circle No. 165, Page 157-158

foundry trade news

ALLOY CASTING INSTITUTE . . . has announced the election of new officers. Elected president was J. B. Dear, Duraloy Co., Scottdale, Pa. New vice-president is J. S. Wooters, General Alloys Co., Boston. New directors are R. W. deWeese, Electric Steel Foundry Co., Portland, Ore., and J. L. V. Bonney, Jr., Bonney-Floyd Co., Columbus, Ohio. E. A. Schoefer was reelected as executive vice-president and treasurer. The institute has recently moved its offices from Mineola, N. Y. to 1001 Franklin Ave., Garden City, N. Y.

STEEL FOUNDERS' SOCIETY OF AMERICA . . . has announced the selection of four winning posters out of 212 submitted in the national 1959 Safety Poster Contest. Winners include C. W. Hunt, Oklahoma Steel Castings Co., Tulsa; T. S. Emala, American Steel Foundries, Verona, Pa.; E. J. Conroy, Electric Steel Foundry Co., Portland, Ore.; and Mrs. Clare Rresenberg, Sawbrook Steel Castings Co., Lockland, Ohio. Winning posters will be on display in S.F.S.A. member plants during the society's three-month annual safety contest.

National Engineering Co. . . . has revealed plans to conduct a contest intended to locate "Handlebar Harry, the oldest Simpson Mix-Muller this side of the cupola." First prize for the contest will be an all-expense trip to Hawaii for two. Other prizes include television sets, shotguns and fishing gear. The contest is open to anyone working in a foundry and any muller manufactured by the company is eligible for a prize, based on a 50-word statement by the entrant. Judges for the contest will be appointed by officers of AFS. Contest closes February 28 and winners will be announced at the AFS Castings Congress at Philadelphia in May.

Magnet Cove Barium Corp. . . . has completed a new sales office and foundry research building at Rolling Meadows, Ill. Magcobar, one of the Dresser Industries, produces western and southern bentonite. The new facility will include a research laboratory with complete equipment for foundry production including an induction melting furnace. The company states that it is the first experimental owned and operated by a foundry supplier. Personnel to be transferred to the new installation include Gerry Morrical, division manager, and Art Zrimsek and George Vingas, foundry research engineers.

Doehler-Jarvis Div., National Lead Co. . . . has announced that a patent for a die cast V-8 aluminum automobile engine block has been issued to A. F. Bauer, assistant general manager and chief engineer of the division. The design eliminates undercuts, projections and blind passages, and allows for the efficient mass production of blocks by die castings. Double wall construction is used to increase strength and rigidity. Mr. Bauer is shown examining a section of the block.

Ajax Magnethermic Corp. . . . has announced the formation of a Canadian subsidiary to be known as Ajax Magnethermic Canada, Ltd., located at Ajax, Ont. The firm will market high and low frequency melting furnaces, billet heaters and heat treating equipment.

Garvey Pattern & Mfg. Co. . . . South Bend, Ind., firm has recently installed a large universal milling machine which enables it to produce larger patterns and to increase the rate of production. The German-built machine was the first heavy equipment to be delivered to the northern Indiana area via the St. Lawrence Seaway.

Magnesium Alloy Products Co. . . . Compton, Calif., magnesium foundry has been licensed by Magnesium Elektron Ltd., Manchester, England, to produce castings by means patented by the English firm. This includes the rights to the "Elektron" alloys of the zirconium rare earth and thorium series as well as a new magnesium-silver-rare earth alloy.

General Electric Co. . . has begun construction of a $500,000 heat treating facility for turbine-generator castings at its Schenectady, N.Y., large steam turbine-generator department. This new facility is part of a $3,700,000 expansion program which will enable the plant to produce steel castings to 100,000 lb. The heat treating installation will accommodate turbine shell and valve castings to 170,000 lb.

Kiowa Corp. . . has announced plans for a $250,000 expansion of its zinc and aluminum die casting plant at Marshalltown, Iowa.

Baroid Chemicals, Inc. . . has announced appointment of Sinclair-Brandt Equipment and Supply Co., Houston, Texas, as sales and service distributor of its foundry materials in Texas.

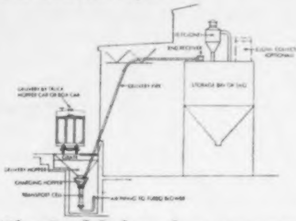
International Minerals & Chemical Corp. . . is recognizing its 50th anniversary by sending a traveling display of historical pictures to its various plant locations. Since 1909, IMC has grown to a nation-wide corporation with 68 mines and plants and annual sales of more than $100,000,000. A major step in the growth of the corporation was the addition in 1951 of the Industrial Minerals Division. Headquarters for the corporation are at Skokie, Ill.

Arthur Tickle Engineering Works . . . has acquired the bi-metallic foundry production of Al-Fin Div., Fairchild Engine and Airplane Corp. Tickle Engineering will transfer Al-Fin's equipment, molds, patterns and some of its key personnel to its Brooklyn foundry. Al-Fin will continue its design, consulting, licensing and supervisory functions.

product report . . .

A savings of $12,950 in one year was chalked up by the South Bend, Ind. foundry of Studebaker-Packard Corp. through installation of a low pressure air conveyor system—enough, according to company officials, to pay for the initial cost of the unit.

This system, designed and installed by National Air-Conveyor Corp., Chicago, receives new, dry sand directly from a hopper car. A low pressure transporter connected to a turbo-blower delivers sand on a continuous basis, via pipe, directly to storage bin or belt conveyor.



The Studebaker plant cites specific savings as follows:

- Closed-hopper cars resulted in yearly savings of $6,750 in paper car coverings and eliminated need for a sand dryer.
- Reduced annual maintenance on clam-shell equipment by $1,200.
- Requires less manpower.
- Less floor and transmission space required.
- Sand delivery is automatic, continuous and faster.

Foundry Switches Ladles on Monorail with Air Cylinder

■ A plant-made, air-operated switch has greatly reduced maintenance of the overhead monorail system handling metal transfer ladles in the foundry of Crouse-Hinds Co., Syracuse, N. Y.

Switching ladles from one monorail to another is necessary in order to deliver metal to six different pouring areas. Formerly, operators gave a hard pull on a cable to throw the switches by hand. This type of rough handling proved extremely hard on both the switch and monorail. The switching mechanism became loose, and parts showed decided wear in short periods of time.

The company's sheet-metal shop got to work and solved the problem by installing a double-action air cylinder to transfer the switches smoothly and at a constant rate of speed, holding wear and tear to a minimum.

The shop mounted a four-way valve air cylinder onto a metal platform, fabricated a bracket for the switch and attached a chain. Now the men give a light tug on the chain to throw the switch.

DESULPHURIZATION...

LINDE's desulphurization method, for use with calcium carbide, is simple, efficient, and economical. The principal parts, shown here, are nitrogen supply, dispenser, and injection tube.

You get uniform results with Metallurgical Carbide from LINDE

In the foundry, you can produce high grade iron only by making sure you use metal with a low sulphur content. As a desulphurizing agent, metallurgical calcium carbide assures *uniformity* in the metal you produce. You know in advance that by adding a certain amount of carbide you remove a certain percentage of sulphur. Because metal specifications can be met efficiently and economically with carbide, you eliminate any need for wasteful "trial and error" methods.

Linde's method of mixing UNION calcium carbide and molten iron is simple and sure. A stream of fine mesh carbide and nitrogen under pressure is forced from a dispenser through a hose. The graphite injection tube is immersed deep in the hot metal. The carbide blends evenly and thoroughly with the iron. Desulphurization with UNION calcium carbide creates no fumes, does not attack refractories. The LINDE equipment—nitrogen supply, dispenser, and injection tube—is easy to operate and maintain.

If you would like more information about LINDE's method of desulphurization, using calcium carbide, just call or write your nearest LINDE office. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

UNION CARBIDE

The terms "Linde," "Union" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

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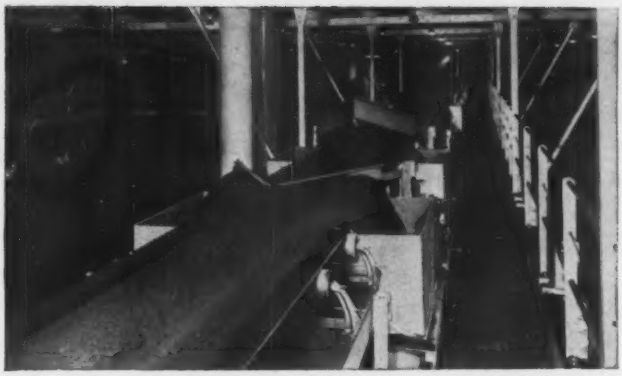
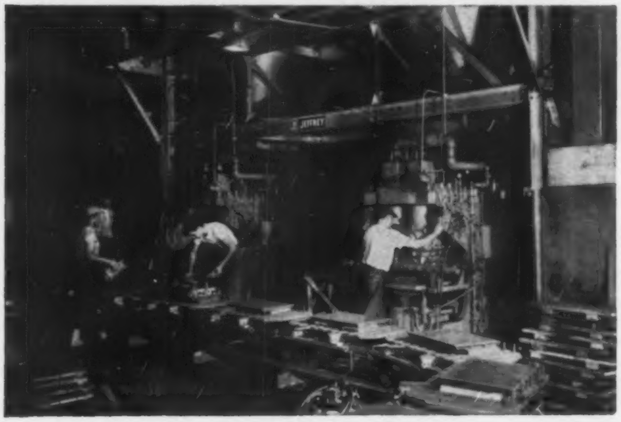
Circle No. 169, Page 157-158

Circle No. 170, Page 157-158



Jeffrey Sand Handling Belt Conveyor with Automatic Plows



Jeffrey Universal Mold Conveyor

Jeffrey Universal Mold Conveyor, Automatic Mold Dumper and Apron Conveyor

Jeffrey Apron Conveyor Handling Castings

you'll see the difference in foundries planned by JEFFREY

MECHANIZATION takes over many operations formerly requiring manpower—from sand preparation and distribution to the molders and core makers, to the pouring positions and shakeouts, then back to sand reclaiming and storage—moving raw materials and processing finished castings. Jeffrey services to the foundry industry are that complete.

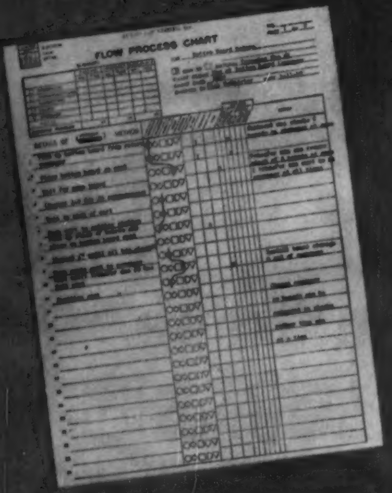
We'll start with a survey, prepare layouts and recommend equipment, build and install a system to suit your exact requirements. We'll alter existing facilities or replace obsolete units with modern, efficient Jeffrey machinery.

Catalog 977 describes these services and equipment. For a copy, write to The Jeffrey Manufacturing Company, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT
TRANSMISSION MACHINERY • CONTRACT MANUFACTURING

Circle No. 174, Page 157-158



work smarter . . . not harder

Peg board problem introduces worker to method of analyzing a foundry operation

Jack R. [illegible]/
Work Simplification Engineer
Texas Foundries, Inc.
Lufkin, Texas

The answer to the above question is "Yes" of course. All foundries would like more profit and desire more employee participation in cost reduction and methods improvement. These dollars and percentages are the present results of the Work Simplification program at Texas Foundries.

And what is Work Simplification? Unfortunately it is a term frequently used but infrequently defined. Is it merely simplifying work? Not exactly. The Society for Advancement of Management defines work simplification as *"the organized application of common sense to eliminate all waste—of time, effort, material, equipment or space."* Allen H. Mogensen, director of Work Simplification Conferences, Lake Placid, New York and Sea Island, Georgia, and the founder of work simplification defines it as "the organized use of common sense to find easier and better ways of doing work." We, at Texas Foundries, say simply, "It is an organized program to utilize the employee's head as well as his hands."

But not even these definitions give a completely clear description of work simplification. One of the major distinguishing characteristics of a work simplification program is the shifting of emphasis in methods improvement from a few "experts" and "specialists" to each and every member of the organization.

Why do we want to shift this emphasis? Because all too often in the past the "expert" who had developed the improvement spent most of his time with problems of installing the improvement, overcoming the workers' resentment and resistance to the change, and then maintaining the improvement in application. By shifting the responsibility of methods improvement to every member of the organization, this resistance and resentment is tremendously overcome.

Thus work simplification utilizes the ideas of employees. There was one word in each of the definitions previously stated that differentiates a work simplification program from the familiar types of suggestion systems. That one word is *"organized"*. It is this organized approach that enables work simplification to obtain the maximum results from employee participation.

LAW OF INTELLIGENT ACTION

In employee participation of methods improvement, you are concerned with people and their reaction to problems. William J. Reilly, in his book, *The Law of Intelligent Action*, says: "When a person is confronted with a problem, the intelligence of his action is dependent on three primary factors:

1. His *desire* to solve the problem.
2. His *ability* to solve it.
3. His capacity to handle the *human relations* involved."

Let us examine work simplification in the light of this law, or more specifically, how Texas Foundries apply this law in its work simplification program.

COULD YOUR FOUNDRY HAVE USED

$600,000 MORE PROFIT IN THE LAST SIX YEARS . . . .

WOULD YOU LIKE TO HAVE ALL YOUR EMPLOYEES SEARCHING

SYSTEMATICALLY FOR WAYS TO REDUCE COST . . . : AND

EVALUATING THEIR OWN JOB EFFICIENCY . . . .

DESIRE TO IMPROVE

The first factor in the law is *desire*. To get our people interested in work simplification, we first acquaint them with our program by holding classes for both the supervisory and hourly workers. The supervisory course involves 13 lessons and the hourly workers, 7. Each lesson is approximately two hours in length. These classes are held after the work day and the hourly workers are paid their regular hourly rate for time spent in class.

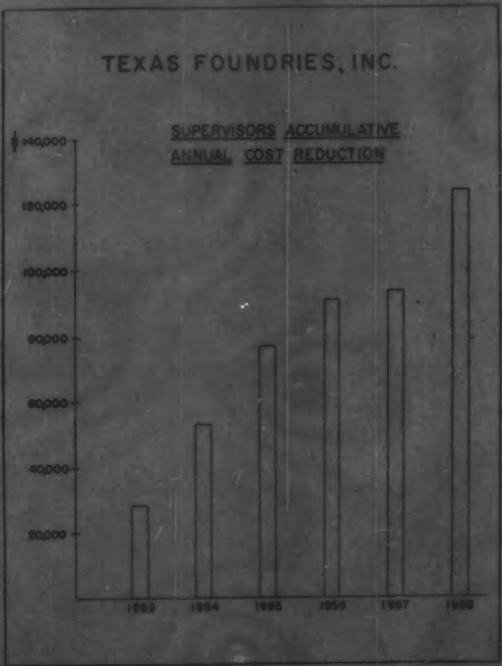
In the first session of both courses, we conduct a demonstration with the common peg board. The instructor requests one member of the group to perform the simple task of placing the pegs in the board, using any method he desires. Then each member of the class takes a turn. A record is kept of the time required for each performance.

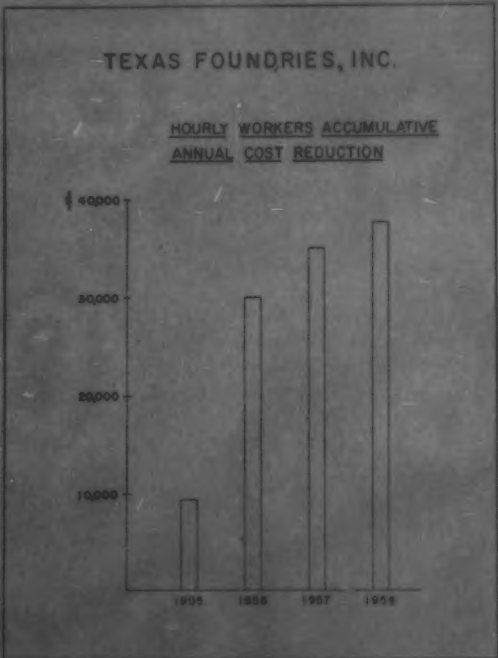
A lively discussion always follows this demonstration with all members experimenting with different methods in an attempt to require less time for the task than any other member.

This experiment proves several interesting things. One is that it is natural for people to want to improve; and unless inhibited, they will try to do so. The instructor is careful not to request any improvement or imply that there would be any competition. However, the natural instinct of the people involved was to attempt to improve. This natural desire aids work simplification. Our problem is to increase it and channel it in the proper direction.

ABILITY TO IMPROVE

The second factor in the law is *ability*—the ability to improve. This ability is also natural. Much class activity is designed to improve the employees' ability





Original method of separating chills, core rods, and metal from spill sand. Operator shoveled sand into the riddle to separate metal objects from the sand.

Improved method of separating metal parts from spill sand by use of electro-magnet was devised by foreman. This new method saves $2436 annually in labor costs.

to make improvements. The first step is to instill in their minds a questioning attitude towards any job they perform or observe being performed. This attitude is extremely important if they are to overcome natural human complacency and tendency to continue in the established method.

FIVE STEPS FOR IMPROVEMENT

After obtaining this attitude of "Why do we do this job this way?", we then teach them a step-by-step procedure for improving that job. These steps are a simple pattern for thinking, similar to the ones used in scientific analysis and problem-solving. These steps are:

1. Select a job to improve

Time is valuable so employees should make the best of it by doing first things first. Improve those jobs which need it the most. We list four types of jobs that should be improved first: (1) a bottleneck job; (2) jobs that take too much time; (3) jobs that take a lot of chasing around; and (4) jobs where there is a waste of materials, time or energy. By discussion and movies of typical jobs in these categories, the employees are oriented to the types of jobs to select first.

2. Get the facts

We stress that the best ways to get facts about a job are by observation and a detailed breakdown of the job. To enable employees to make a proper breakdown, we acquaint them with some of the charting and analyzing techniques of Industrial Engineering. The hourly worker's sessions deal primarily with the flow process chart and how to utilize it to obtain details of each job step. They also become familiar with the multiple activity chart and the operator chart.

In the supervisory sessions, these are included along with some of the more detailed procedures. These sessions include work sampling, simo charts and film analysis. Supervisors only become familiar with these advanced techniques, not proficient in their use. This familiarizes them with the use of these techniques. If they have occasions to use them, assistance from the Industrial Engineering Department is available.

3. Challenge the job and then each detail of the job

The flow process chart used is especially designed to aid in this challenging. It contains a section for guiding the user in a systematic approach to challenging each detail of the job. The ultimate goal is to eliminate the job completely. If this is impossible, then the chart suggests eliminating or combining some elements, changing the sequence, place, or person, or just simplify the method of performing the detail.

4. Develop the improved method

In this step, the employees are instructed in some of the fundamentals of motion economy and how they are helpful in pointing out a method that needs improving. They are instructed in how to choose between several alternate methods and also reminded to consider both the economic and human factors.

5. Install the improved method

This is the ultimate goal of the first four steps. We stress that following this pattern assures maximum results in methods improvement. "Do you really have to follow all those steps to improve an operation?" That is a question our employees frequently ask us. Yes, it may seem slower to follow the pattern but the additional improvements obtained that are normally overlooked in a "flash improvement" will more than compensate for any delay.

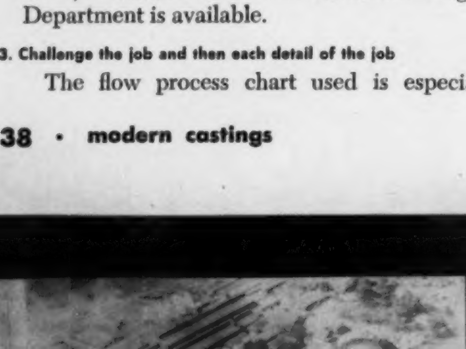
THE HUMAN FACTOR

With this pattern, and the accompanying techniques, the employee is capable of determining improved methods. But whether he will be a success at improving jobs in the foundry is determined by the third factor in our law of intelligent action—his ability to handle the human relations involved. So we stress in class the human factor—how to get results through people and how to overcome resistance to change and criticism. For this instructional phase, we have developed our own work simplification booklet so that our material will be more personalized.

APPLYING WORK SIMPLIFICATION

We are now ready to harvest some of the seeds we have been sowing. But this harvest does not come automatically. Instead, it must be encouraged by programming the *application phase* as thoroughly as the *instructional phase*.

To guide this programming, Texas Foundries has established a work simplification general committee



composed of five top executives and the work simplification engineer. The superintendents of the five major manufacturing divisions act as advisors to this committee. The committee establishes goals and procedures for the program.

In each department a work simplification committee is formed with the departmental supervisor as chairman. This committee is composed of all departmental foremen and any other departmental members of the management staff. Currently there are 11 such committees, each composed of from three to six members.

Committees gather facts on problems and develop proposed methods by both group and individual action. The group meets formally once a week for consultation and planning. The work simplification engineer attends these meetings as an advisor and as a secretary to record the minutes of the meeting.

Projects, not suggestions, are of most interest in work simplification. The employees do not submit suggestions for the Industrial Engineering Department to investigate and complete; instead, *the employee submits a proposal for a possible improvement and he follows it to completion.*

A work simplification project progresses through the following stages:

1. An employee decides a job can be improved and records this on an "Initial Proposal Form." He takes this form to his foreman and superintendent for their approval and signature. Form is submitted to the work simplification section. If the job is considered eligible for investigation, the work simplification engineer grants him a project priority for 90 days. This priority guarantees that only one employee will be investigating a particular job.

2. The employee uses the simplifying techniques he has learned to chart and challenge the details of the job and to develop an improved method. He also arranges for any experimental trials that must be conducted.

3. The employee makes a final proposal listing the details of his improvement and the estimated yearly savings. He again obtains his foreman's and superintendent's approval and signature and submits the form to the work simplification section. The work simplification engineer reviews and checks all aspects of the proposal before approving. It is then reviewed by appropriate managers, including the president. If approved the improvement is installed. At the completion of installation the project is finished.

RECOGNITION

Texas Foundries believes that the key factors in maintaining an active work simplification program are *motivation and stimulation*. Thus, when a project is completed several methods assure the employees that they will receive the deserved recognition.

First, a work simplification certificate is presented by the president for each project completed.

Second, the individual's picture is posted on the bulletin board.

Third, every project is reported in the plant newspaper with a picture of the "before" and "after" included.

Fourth, an annual report on work simplification is distributed to all employees. It contains the name of everyone completing a project in the previous year; gives special recognition to the individual who completed the most projects during the year; and commends the individual whose project resulted in the largest saving.

Fifth, the employees are eligible for a cash award when their project is installed and in operation. The awards are based on 15 to 25 per cent of the net cost reduction during the first year for the hourly workers and 3 per cent for the supervisors. The supervisors in their departmental work simplification committees are also in competition with the other committees. The committee obtaining the largest cost reduction by projects completed during each quarter of the year receives a $100 gift certificate.

Sixth, movies are made of outstanding projects and shown to the workers during the lunch period.

TOP MANAGEMENT INFLUENCE

Undoubtedly the most important factor in the success of a work simplification program is the enthusiastic backing and participation of top management. And Mr. Top Manager, this means *enthusiastic backing* and *participation*. For your employees will be only as enthusiastic and eager to participate as you are. It is your recognition that many employees are seeking by participating in this program.

At Texas Foundries work simplification is referred to at nearly every plant or management group meeting. The president or works manager presents the certificates and award checks to the employees and compliments them for their projects. This constant association by top management with the program

Original method of storing core gages. This job was investigated and improved by an hourly-pay employee.

Improved method. Gages are stored on rack identified with customer's name. New method saves $88 per year.

Supervisors receive trophies from president of company in recognition of unusual effort in developing work simplification projects.

assures all employees that top management is interested in work simplification.

THE RESULTS

Now let's take a look at the results obtained.

Page 37 shows the results which have been achieved since 1953 by supervisory projects that were processed through the work simplification section. Since the savings on each project continue yearly, the total savings are shown on an accumulative basis. The total accumulative cost reduction by these projects in the six year period is **$464,500.**

Page 37 also shows the results obtained from projects installed by the hourly workers since 1955. Notice that the hourly groups started off slower than the supervisory group. This reflects the fact that their projects are usually much less complicated. However, as more workers were trained the volume of projects and dollars saved increased. The accumulative savings by these projects in the four year period is **$111,800.**

Thus, the systematic problem solving techniques of work simplification have been responsible for a total cost reduction of **$576,300** since 1953.

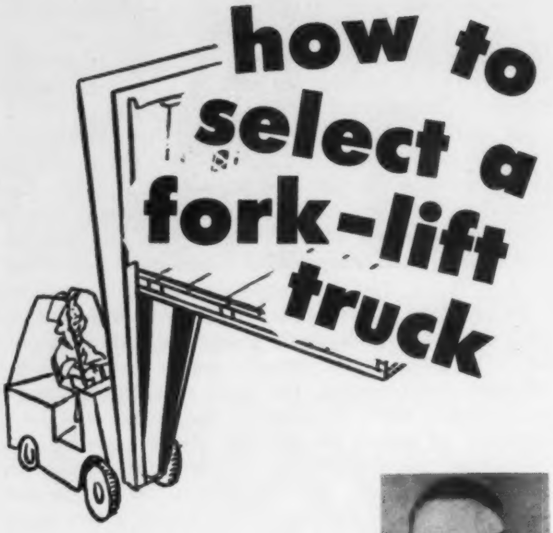
These results were calculated only on projects that were formally processed through the work simplification section. Many other improvements have been made as a result of class discussions and the application of the systematic approach without a formal project.

These savings have indeed been gratifying; however, we feel that the improvement in our employees' morale and the decrease in their resistance to change have actually been more important than the direct cost reduction. Management now notices a definite improvement in receptiveness to new methods and equipment. Cooperation at all levels is greatly improved.

The basic philosophy of work simplification can be applied successfully in any organization. With the proper appreciation, education, application and programming, it is one of the best techniques known for cost reduction and improved human relations.

Texas Foundries has found that this organized use of its own employees' common sense has definitely resulted in better and easier ways of doing work. ■ ■ ■

how to select a fork-lift truck



by W. A. Meddick/*President*
Elwell-Parker Electric Company
Cleveland

One of the most difficult problems faced by a potential user of industrial lift trucks is the lack of knowledge of factors pertinent to the selection of such equipment. To meet this problem, the following paragraphs discuss many of the most important areas of consideration: capacity, lift, size and weight, location of operator and truck controls, mechanical design and battery capacity where electric-powered vehicles are desired.

Specific Features

Foremost of all considerations is one basic rule which refers to the economical purchase of any industrial truck: When buying a truck, it is best to specify one that will meet average requirements. To buy a truck to cover every conceivable problem is neither economical nor practical because normally the expense is not justified. For example, if loads occasionally must be tiered four-high, although the majority are tiered only three-high, an extra high-stacking truck for just the occasional job is uneconomical.

Or if 95 per cent of the loads to be handled weigh 4000 lb each, it is not practical to purchase a 6000-lb capacity truck for occasional loads of the greater weight. Instead, the best solution is to devise another method to handle the infrequent requirements.

The degree of mechanized handling obtainable with industrial trucks also increases a given plant's volume For instance, the carrying of two 2000-lb loads simultaneously with a 4000-lb truck is usually more economical and efficient than handling one 2000-lb load with a model of corresponding capacity. To plan the most efficient handling techniques is just as important, or even more so, than choosing the right truck to do the job required.

Factors Governing Lift

Although the stacking of loads to ceiling limits is often advisable, other factors must be considered: (1) will loads withstand the weight of other loads on succeeding layers of the stack; (2) will floors take the strain of the total load; (3) are the industrial trucks stable enough for extra-high stacking.

Every conceivable factor of safety must be considered when handling extra high loads. For example, if the wheel of a truck should drop into a slight depression in the floor, a load elevated 15 feet might move laterally as much as an entire foot. This might be sufficient to tip the truck. Likewise, if a package falls from a load high in the air, enough momentum is gained to inflict serious damage to itself or whatever it strikes at ground level. Then too, the uprights of a truck tend to twist when they are extra long creating both a physical and maintenance hazard.

With telescoping fork trucks, a two-inch increase in lift generally means a one-inch increase in the collapsed height of the truck. If an extra high lift is specified, the resultant height of the truck when collapsed may prevent passage through doorways or under low-hanging pipes or beams.

If a truck is employed for car or truck loading, its collapsed height should permit entry into the carrier. Most truck manufacturers build a 68-inch-high model for carrier loading. But unless a truck has full initial lift (the ability of the forks to rise without increasing the over-all height of the truck), tiering of loads within low headroom areas may not be possible.

Specifying the height of a truck's lift beyond the standard may prove costly. Several methods have been developed to permit high tiering without increasing the collapsed height of the truck; one is the use of triple telescoping uprights. Although workable, this arrangement tends to reduce truck capacity and usually increases cost.

Total Weight and Size

One of the most important factors in determining the total weight and size of a truck is the floor loading capacity over which trucks must operate. Other factors include elevator capacities as well as floor loading capacities of highway trucks and rail cars.

As a general rule, floor load capacity is figured in terms of a static load. However, when computing the weight of a truck in relation to the floor capacity, the weight exerted by a truck must be computed in terms of a live load. Moreover, the weight of the truck plus the heaviest load the truck will carry must be considered.

Because many companies are demanding more compact industrial trucks, the problem of floor load capacity is becoming more acute than ever before. Certain types of trucks are designed for operation on weaker floors; some trucks are either basically smaller or are designed to distribute their weight over a greater area. In any case, consultation with industrial truck manufacturers is strongly advised, both on computing floor load capacities and in selecting the truck to best fit a given situation.

Where the truck rides the elevator with its load, the heaviest load such a vehicle will carry must be included in the total allowable figure.

Some companies have skirted this problem by having load and truck ride separately. Others use smaller, lighter-weight vehicles to load and unload elevators or even ride with the loads. This leaves the heavier, faster vehicles to work only on the floors.

Truck size may further be limited by the physical areas in which the unit must work. For example, narrow aisles, confined production or storage areas can limit a truck's over-all size, and subsequently, its capacity. All areas in which a truck will operate must be studied to find the safe, allowable size limit.

Because their basic design distributes the over-all weight more evenly, powered platform trucks may be adapted to areas where fork trucks cannot operate effectively.

Operator Location

Still another important consideration is the location of the truck controls and position of the operator. Basically, three optional designs can be obtained: (1) center control sit-down; (2) center control stand-up; and (3) end control stand-up. Although position of driver is often a matter of personal preference, certain advantages can be obtained from locating an operator in different areas of a truck. Most all standard fork trucks in capacities up to 10,000 lb are the center control sit-down type. Primarily this is for the comfort of the operator, but also, the operators are more easily trained, since automobiles are operated from this position.

Many companies prefer to have the operator stand, either in the center or at the end of the truck. They believe this keeps the operator wide awake and more alert than when he is allowed to relax in a sitting position. Conversely, others feel this tends to tire the operator needlessly. One factor favoring stand-up control is that operators can move on and off the trucks quickly and easily.

With stand-up end control, the operator has the entire truck in front of him. Therefore he need not worry about the back half of the truck striking obstacles not within his immediate view.

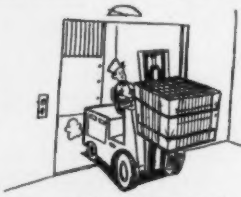
Center control places the operator closer to the load being picked up and positioned. Under many conditions, this is an advantage.

Among the mechanical features to be considered are such components as the drive axle, trail axle, controls, steering chuck, lifting mechanism, and others. Such features are best decided with the truck manufacturer, but may also be tempered by the user's own experience with such components in other equipment as well as in industrial trucks. For example, if a user has found that a worm drive proves efficient on other equipment, he might favor a worm drive on his industrial truck.

Battery Capacity

The foregoing data relate to both gas and electric-powered vehicles. But where plant conditions indicate a preference for the latter type of truck, the selection of a suitable battery to permit the vehicle to perform properly throughout the working day becomes an additional pertinent consideration.

In order to figure required battery capacity one must analyze the truck duties such as: lengths and frequency of travel, required number and height of lifts, action of any attachments, amount of jockeying the truck must do (in loading and unloading), the number of starts and stops, whether tilt is required, and whether ramps are to be negotiated.



Even though certain alterations can be made in the overall truck design to accommodate a larger than normal battery, and even though certain new battery design features give greater output with a smaller battery, the fact remains that the truck's size and battery capacity must be compromised to insure maximum operating efficiency.

Most important of all to remember in specifying features of an industrial truck is that the manufacturer, or his representative, is a helpful person to consult in determining your specific specifications. Because of his experience with other companies, the manufacturer occupies the most favorable position to know what features make a truck most effective and economical to operate ■ ■ ■

IN PURCHASING AN INDUSTRIAL TRUCK

When Specifying — Take into Consideration

CAPACITY
- **Size and Weight of Loads Most Often Handled**
- **Possible Increased Load Size & Weight**

LIFT
- **Greatest Stacking Height Feasible Minus Height Of One Complete Load Unit**
- **Allowable Collapsed Height Of Truck**
- **Maximum Weight Withstood By Bottom Load In The Stack**
- **Maximum Weight Withstood By Floor**
- **Maximum Stability Of Truck During High Stacking**

TOTAL WEIGHT AND SIZE
- **Floor Load Capacities**
- **Elevator Capacity And Size**
- **Aisle Widths**
- **Limitations Of Confined Areas**
- **Floor Capacities Of Carriers**

BATTERY CAPACITY
- **Length & Frequency Of Travel**
- **Lift**
- **Tilt**
- **Action Of Attachments**
- **Whether Ramps Are Travelled**
- **Amount Of Truck Jockeying**
- **Length of Working Shift (Day)**
- **Size Of Truck**

LOCATION OF OPERATOR
TRUCK CONTROLS
- **Individual Company Operating Conditions**

MECHANICAL FEATURES
- **Individual Preference**

THE EIMCO CORP. DEVELOPS . . .

new steel alloy

by JACK H. SCHAUM

A new family of steel alloys may provide better heavy duty castings for the road-building, construction, railroad and mining industries. Among such castings are caterpillar tractor treads, railroad frogs and switch components, ball mill liners and jaw crusher plates.

• The new alloys are challenging the virtual monopoly held by austenitic manganese steel as the number one rugged material for these applications. In the words of co-inventors John N. Carter and Donald N. Rosenblatt, The Eimco Corp., Salt Lake City, "this new cast alloy steel obtains its unusual properties from the presence of a fine dispersion of alloy carbides in an austenitic matrix." The carbides supply built-in hardness to resist wear when the abrasive forces are at stress levels too low to produce enough metal flow to work harden the austenite on casting surface.

• Austenitic steel does not become hard until subjected to severe abrasive stresses. Under these conditions the metal on outer surface flows, producing "work hardening" that converts soft austenite to extremely hard martensite.

• Unalloyed plain carbon steel normally has a microstructure of ferrite and pearlite—making the steel relatively soft and ductile. Alloyed with the proper quantities of Mn, Ni and Cu, steels develop an austenitic microstructure with great strength and toughness, high resistance to erosive and abrasive wear and marked sensitivity to work hardening.

Advantages of Patented Cu-Ni Steel Alloy System

1) **Has high resistance to erosion wear at low hardness level flow stress.**
2) **Resists flow under impact—avoids buckling, binding and distortion.**
3) **Can be field-welded because there is no embrittlement in heat-affected zone.**
4) **Can be heat treated in sections up to 10 in. without forming undesirable grain boundary carbide.**
5) **Low Mn content prevents problem of carbides in grain boundries.**
6) **Easily handled in foundry because it is not brittle in as-cast condition.**
7) **Can be made in acid or basic furnace.**
8) **Dispersed carbides supply wear resistance without need for work hardening.**
9) **High hardness levels attained with much less impact energy required.**
10) **High corrosion resistance.**

• This hard skin accounts for the ability of austenitic alloys to resist erosive and abrasive wear of the sort that a jaw crusher would be subject to when breaking up hard mineral-bearing rock.

• According to Carter and Rosenblatt, this new alloy uses approximately three per cent copper and 6.5 per cent nickel to develop an austenitic matrix, instead of the 11-15 per cent manganese contained in conventional austenitic manganese steel. The finely dispersed hard carbides are formed by the 2-5 per cent Cr, Mo, Va, W, Cb and/or Ti present in the alloy.

• This Ni-Cu alloy steel has the additional advantage of responding to heat treatment without being subject to embrittling side effects. Manganese is a desirable element to form austenite but unfortunately it is also a carbide former. At certain temperatures iron manganese carbides will form at the grain boundaries of the austenite and make the steel brittle.

• Recommended heat treatment for developing optimum physical properties in the new alloy is shown in Table 2. The first stage anneal homogenizes the austenite structure and puts all the carbon into solid solution. Holding 1-3 hr at about 1700 F precipitates out the hard, stable carbides of Cr, Mo, Va, W, Cb and Ti ideally as spheroids within the austenite grains. The steel is then rapidly cooled to room temperature by quenching in brine, oil or water. It is now ready for service with optimum structure of finely divided spheroidal carbides uniformly dispersed throughout an austenitic matrix.

■ This alloy is suited for the rugged applications cited because it develops:

Unnotched charpy impact strength	= 120 + ft-lb
V-notch charpy impact strength	= 20 + ft-lb
As-cast hardness	= 220 Bhn
Hardness when subjected to work hardening	= 620 Bhn

Complete details are covered in U.S. Patent No. 2,751,291.

■ ■ ■ ■ Table 1—Patented Alloys ■ ■ ■ ■

	No. 1[1] (%)	No. 2[2] (%)	No. 3[3] (%)
C	0.85-1.3	0.85-1.3	0.95-1.05
Mn	0.5-2.5	0.5-2.5	1.0-1.5
Cu	1.5-4.5	1.5-4.5	2.5-3.5
Ni	5.0-10.0	5.0-10.0	6.0-7.0
Cr	3.0 (max)	3.0 (max)	0.5-1.5
Mo	3.0 (max)	3.0 (max)	0.25-0.5
P	0.15 (max)	0.15 (max)	0.15 (max)
S	0.1 (max)	0.1 (max)	0.1 (max)
Si	1.5 (max)	1.5 (max)	1.5 (max)
Va	1.5 (max) of one of these elements (Va, Ti, Cb, W)	1.5 (max)	0.75-1.0
Ti			
Cb			
W			
Fe	balance	balance	balance

1) Total Cr, Mo, Va, Ti, Cb, and W = 2% (min)—5% (max)
2) Total Cr, Mo, and Va = 2% (min)—5% (max)
3) Total Cr, Mo, and Va = 2% (min)

■ ■ ■ ■ Table 2 – Heat Treatment ■ ■ ■ ■

Alloy No. 1 & 2

First Stage Temp	First Stage Time	Second Stage Temp	Second Stage Time	Third Stage
1900 F (min)	Several hours	Cool to 1700 F	Several hours	Rapid quench

Alloy No. 3

First Stage Temp	First Stage Time	Second Stage Temp	Second Stage Time	Third Stage
1900-2100 F	4-8 hr	Furnace cool to 1650-1750 F	1-3 hr	Rapid quench

by J. G. WINGET,
Reda Pump Co.
Bartlesville, Okla.

high-speed melting

How often have you been faced with a need for a piece of foundry equipment that had not yet been invented? If the problem becomes sufficiently acute, you might even attempt to create a device to solve your needs. Under the duress of such necessity, Reda Pump Co., a pump manufacturer of long standing, suddenly found themselves in the business of manufacturing melting furnaces.

Specialized melting requirements sowed the seed of invention at Reda Pump. With the advent of ductile iron, a number of applications were recognized in the pump business. Existing tilt-type crucible furnaces used for iron melting proved too slow and costly for the production planned in ductile.

Finding satisfactory commercial melting equipment was complicated by three factors:

1) The equipment had to be "clean" in operation, with minimum discharge of solids into the atmosphere. The Reda plant is located near the center of Bartlesville, Okla., a city of 35,000 that prides itself on being one of the cleanest in America and "the ideal family center" of the nation. The foundry has as immediately adjacent neighbors a soft drink manufacturer, a major oil company's geophysical laboratory and the largest laundry and dry-cleaning establishment in the city.
2) The equipment had to be versatile in handling a variety of ferrous and non-ferrous alloys planned for production without contamination or waste of alloy materials. This made a small, batch-type furnace necessary.
3) Operation had to be at maximum economy. Because natural gas is both readily and continually available at low cost, it was obviously the fuel most practical to use.

Management of the company canvassed the manufacturers of equipment on the market at that time but were unable to locate equipment to satisfy all these requirements. As a result, Reda decided to build its own equipment to make iron castings that would be of equal quality to those made in the prior practice. The melting operations described in this article were performed in the Reda-designed furnace which met all the requirements specified.

Reda Pump Co. is the largest manufacturer of submergible motors and pumps used for pumping different liquids, including oil, brine, water, gasoline and jet fuels. To service the varied industries and customers, Reda requires different alloy materials for pump and motor castings. The foundry operation at the Reda Pump Co. is unique in the diversity of alloys and metals melted.

About 40 workers produce an annual melt total over 3,750,000 lb. Of this total melt, some 2,250,000 lb are in red brass and tin bronze alloys and over 1,500,000 lb in gray iron, alloy iron and ductile iron. Figure 1 is a view of the melting room and Fig. 2 is a dimensioned sketch which shows the furnace locations, metal storage areas, etc. Figure 3 is a sectional view of the special furnace, designed and manufactured at Reda. Due to the size of Reda castings, the charge size in brass and bronze alloys is usually only 200 lb, while iron alloy charges are 500 to 600 lb.

Figure 4 shows typical brass and/or bronze castings made in the Reda foundry. The castings must combine excellent machinability, corrosion resistance and wear resistance—particularly metal-to-metal wear resistance (impellers rotate at 1800 to 3600 rpm). Consequently, castings must be free of porosity and foreign inclusions.

The average daily production in brass and bronze is 42 heats of 200 lb each. This production is generally produced from one furnace, with a second being

YES . . . HIGH SPEED MELTING IS HERE . . . MELT 600-POUND HEATS OF IRON IN 25 MINUTES . . . ONLY 7 MINUTES NEEDED TO MELT DOWN 200 POUNDS OF BRASS . . .

used on occasion when the demand for metal is exceptionally high. One man does all weighing, charging, furnace tapping and alloy adding to the pouring ladle or crucible. The average time for melting a 200-lb charge ranges from 6-1/2 to 8 min, depending on the alloy and the temperature required. Charging time per heat is 1-1/2 to 2 min. The melter then has approximately 5 to 6 minutes for weighing up the next charge, keeping the melting area clean, etc.

Charge metal consists entirely of secondary ingot plus foundry and machine shop returns. Borings and turning chips are returned to the ingot manufacturers to be converted into ingot. This procedure was found to be more economical than melting them in the foundry, due to the difficulty of keeping the chips from the various alloys completely segregated.

Time consumed in melting is dictated entirely by the alloy and the pouring temperature for the particular casting in production. Metal is tapped into 200-lb capacity crucibles. They must be hot enough to prevent metal solidifying on the side walls and to prevent excessive loss of temperature from the metal. Tap hole is located so low in the furnace that tilting of furnace allows metal to completely drain. After the metal is skimmed in the crucible, a skim cover is placed on top to protect the metal from the atmosphere.

This cover has several advantages:

1) It does an excellent job skimming as the metal is being poured into the molds.
2) It prevents excessive temperature loss.
3) It provides a uniform and controlled metal stream in pouring.
4) It makes a significant reduction in smoke and fumes from the metal during the pouring operation.

Not only does the crucible cover keep lead fume concentration down to a safe level but it stops the greater percentage of mis-run problems coming from cold metal.

Metal should be tapped from the Reda furnace as quickly as possible after the correct pouring temperature is reached. Obviously, it is not good practice, from the metallurgical standpoint, to superheat these alloys. In addition, it is poor economics to waste fuel, time and metal by overheating.

Metal losses, i.e. burn-out, are somewhat higher with this reverberatory-type furnace than with crucible furnaces, *per unit of time*. Zinc loss, on a 10 per cent zinc alloy, will average 0.50 per cent to 0.75 per cent. The loss is largely due to volatilization rather than oxidation of the zinc. An addition of 0.6 lb of zinc per 100 lb of metal in the pouring ladle is standard.

A typical day's production in iron alloys is: 7 heats of type 1 Ni-Resist alloy, 5 heats of ductile iron, and 2 or 3 heats of ductile Ni-Resist alloy. Weight of castings will vary from a few ounces to about 300 lb. Typical ductile iron castings are shown in Fig. 5.

Iron alloys are melted in heats ranging from 250 to 600 lb per heat. As in the brass and bronze section, two high-speed Reda furnaces are available for melting iron base alloys. However, only one furnace is used, except on occasions when more metal is needed during a rush period. By using only one furnace at a time, the furnace repair work can be handled on

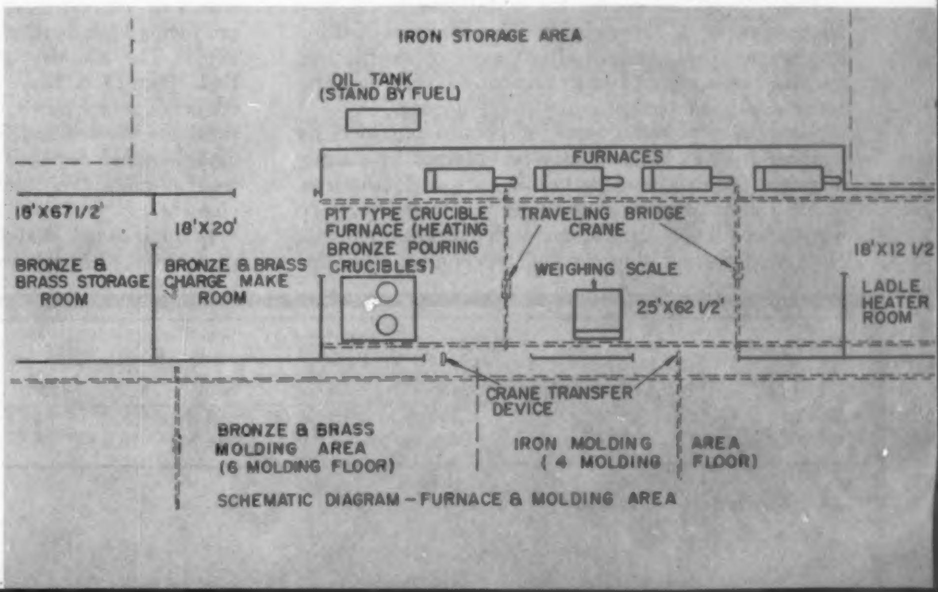
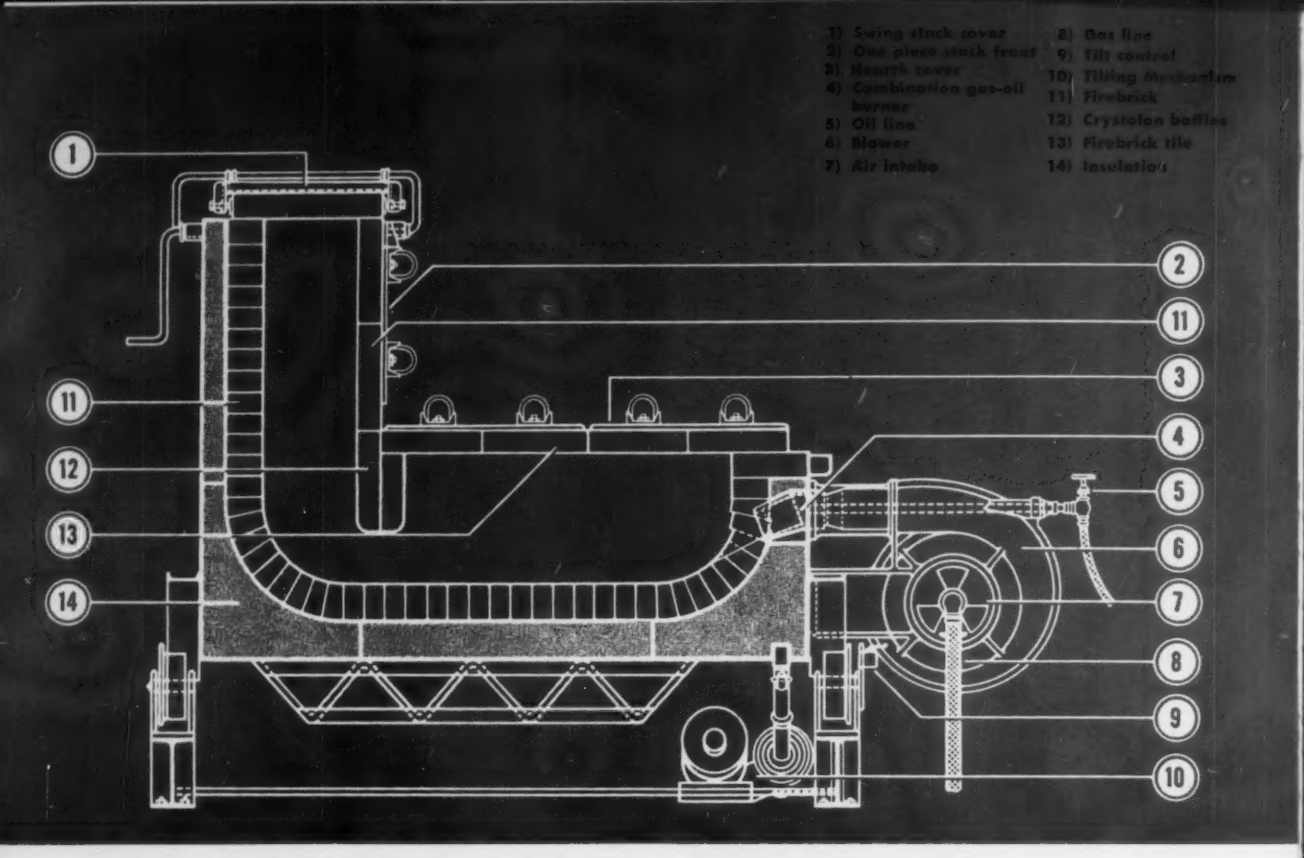


Fig. 2 . . . Annual production of this shop is over 1875 tons of metal produced in 200 to 600-lb heats. Production includes 1125 tons brass and bronze; 750 tons of ductile and alloy iron.



regular time and without undue rush on the part of the foundry maintenance crew. One man does all the work of melting, including charge weighing, furnace charging, alloy weighing, furnace tapping, and pouring-ladle maintenance, etc. Average melting time per full heat charge is 24 to 26 min. depending on the particular alloy and the required pouring temperature.

No scrap is used in this operation. It was found more economical to use pig iron and plant returns than to purchase, sort and prepare scrap for charging into the furnace. Regular foundry grade pig iron is used for gray iron and Ni-Resist alloys. A special grade of low-phos, low-sulphur iron is used for ductile iron and ductile Ni-Resist alloys.

The over-all allowance for metal loss in all iron alloy work is 7-1/2 per cent. This includes melting loss, waste in skimming, spillage, sawing (ductile iron and Ni-Resist alloy castings are cut off with an abrasive cut-off machine), grinding and chipping.

Some idea of the degree of control obtained by melting in Reda furnaces may be obtained by a study of properties exhibited by tensile bars of ductile iron. Table I lists properties taken from records of specimens tested in a recent three-month period.
Note that during this time all specimens exhibited properties that were well above the minimum specification.

In both ferrous and non-ferrous melting the proper melting atmosphere must be maintained within the furnace at all times. A reducing atmosphere is essential for both groups of metals. If not, element losses will be excessive and inferior metal quality will result. Reducing conditions are characterized by 1) a long, lazy flame, 2) clear, shiny metal bath, 3) decrease in smoke and 4) elimination of sparks from iron melts. This one operating technique of the furnace has led to much contradiction, discussion and wonder in the industry—particularly in the non-ferrous field.

Technologists and general practitioners of the non-ferrous industry generally agree that an atmosphere which is "slightly oxidizing" in nature is essential for producing high quality castings of brass and/or bronze alloys. The foundry management and engineers of Reda Pump Co. have no argument with this accepted belief when these alloys are melted in more conventional, slower melting furnaces. Gas absorbtion in molten metal depends on temperature and time, as well as affinity of the particular metal for a given element.

In high-speed Reda furnaces, molten metal is exposed to the furnace atmosphere for such a short time

TABLE I

Condition	No. Tests	Tensile Min.	Tensile Max.	Tensile Avg.	Red. Area (%) Min.	Red. Area (%) Max.	Red. Area (%) Avg.	Elongation (%) Min.	Elongation (%) Max.	Elongation (%) Avg.
As-Cast	10	102,500	121,000	108,450	1.4	1.8	1.75	3.10	3.75	3.54
Annealed	72	62,300	90,300	71,413	10.8	15.8	15.2	12.5	26.6	20.2

(3-1/2 to 6 min. with one-half charges; 3-1/2 to 11 min. with full charge) that gas absorption is no problem. Since pressure-tight castings comprise a large percentage of the company's production, this practice is substantiated daily. Most of these castings are machined over at least 50 per cent of the surface.

High-speed melting yields higher physical properties for a given brass or bronze alloy compared with the same alloy melted in a gas-fired crucible furnace and poured at the same temperature. Fluidity also appears somewhat better, probably as a result of the reducing atmosphere. Alloy iron casting properties are also consistent with published figures.

Furnace maintenance is relatively simple. New or newly repaired firebrick linings are dried out slowly and completely with a gas burner directed through the tap-hole. This burner also keeps lining hot during shutdown periods such as lunch hour, overnight and week ends. With brass or bronze melting, furnaces operate for at least four full weeks before needing any maintenance.

During this period no daily clean-out or maintenance work of any kind is required. With iron melting the higher operating temperatures lead to a need for more frequent repairs. A newly repaired lining runs at least two full weeks before the lids are removed for minor repairs. Seldom is a lining totally replaced. Severely eroded brick is easily replaced or patched with a monolithic mullite material. Firebrick linings last so much longer in this reverberatory furnace (melting iron) than in a cupola because there is no flux or other foreign materials used for cleaning impurities from the iron.

Gas consumption for melting brass and bronze is approximately 25 to 30 cu ft per min. Total fuel consumption per pound of metal melted will depend on: 1) the efficiency of the furnace operator, 2) getting each heat out of furnace quickly as the correct pouring temperature is reached, 3) speed of recharging and 4) on the condition of the furnace.

In Reda's operation, gas consumption per 200-lb charge is approximately 360 cu ft. This includes the gas torch used overnight and week ends plus the gas used in preheating to operating temperature in the morning. At a cost of 20 cents per 1000 cu ft for natural gas, fuel cost per pound of brass or bronze alloy is 0.036 cents.

Melting iron alloys requires 2500 cu ft of natural gas per heat or approximately 5 cu ft per pound of metal melted. This gives a fuel cost of 0.10 cents per pound of metal melted, including 8-hr operating time per day, 1 hr preheating, plus the torch for keeping the lining hot when the furnace is not in operation.

Fuel cost is considerably higher when using oil. To melt brass and bronze, 17.5 gal of No. 2 fuel oil per hr are required. Nine hours of furnace operation (1 hr preheat and 8 hr melting) consumes 157.5 gal of oil. With 200-lb heats, 40 heats per day, oil consumption will be 3.94 gal per heat. The iron melting furnaces require 24 gal of fuel oil per hour, 216 gal per day, or 2.8 gal per 100 lb of iron. In Oklahoma fuel oil is more than three times as expensive as natural gas.

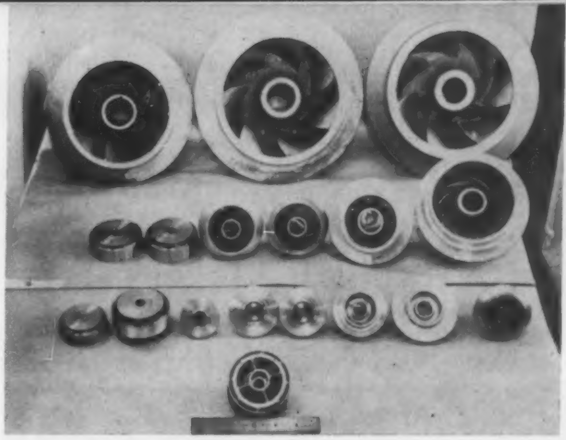


Fig. 4 . . . Typical brass and bronze pump castings.

The furnaces at Reda Pump Co. are equipped for oil firing for demonstration purposes. Also, the gas company allows a more favorable rate to industries equipped with alternate fuel equipment that permits shutting off gas mains during emergencies.

Oil firing is often preferred in melting of iron alloys because there is less tendency toward oxidation. By using a ratio of 80 per cent gas and 20 per cent oil, the oil serves as "insurance" against oxidation of the melt. Being higher in Btu content, oil permits furnace operation on the reducing side, yet still furnishes sufficient heat for a fast operation.

There is generally a slight carbon loss, particularly when melting the higher carbon-equivalent irons. With a base carbon of 3.90 per cent in charges, the carbon in the casting will average between 3.60 per cent and 3.75 per cent, depending on pouring temperature required. For Ni-Resist iron alloys a charge averaging 2.95 per cent carbon will show no appreciable carbon loss. To minimize carbon losses, tap the metal soon as pouring temperature is reached.

The biggest brass and bronze production items are in alloys of the same class, making it entirely feasible to follow one heat with another of different, but similar, alloys. At times the furnace will be operated for only 1-1/2 to 2 hours per day on brass and bronze—certainly not conducive to maximum efficiency. However, it is still much cheaper than melting in the crucible furnaces.

The biggest single benefit derived from melting iron in these furnaces is the production flexibility. Being able to pour iron throughout the day eliminates any need to tie up flasks, jackets, boards, floor space, etc. with molds, as is customary in many iron foundries. The Reda foundry can also make a casting of any of the alloys named, on short notice. ■ ■ ■

Fig. 5 . . . Ductile castings from 9½ oz to 240 lb.

SHELL MOLDING IS HERE TO

STAY . . . BUT WATCH OUT

FOR PRODUCTION PITFALLS . . .

HERE ARE SOME ELEMENTARY

DO'S AND DONT'S . . .

primer on shell molding

23-lb motor frame demonstrates surface finish obtained with shell molding.

by James J. Silk
Shell Mold Supt.
Taylor & Co.
Brooklyn, N. Y.

Since it's inception years ago the shell molding process has been a constant challenge to the ingenuity of the foundryman to produce a superior product and has ultimately become a permanent production technique in the general foundry picture.

However, some of the discouraging experiences with shell molding have caused less patient foundrymen to abandon their efforts before investigating its full possibilities and evaluating its usefullness. Often these shortcomings arose from the failure to recognize the basic fundamentals of good foundry practice.

Foundrymen must first understand the limitation of designs and sizes of castings that can be consistantly reproduced economically in shell molds. This article has been prepared to help avoid some of the pit-falls inherent in this operation and to guide foundrymen demonstrating some proven criteria to insure uniform results.

Most of the information is based on empirical data gleaned from the manufacture of thousands of castings by the shell process over a period of years.

Casting Design

The design of shell molded castings is important as some shapes do not lend themselves to this process. Broad flat castings above 5-in. diameter are inclined to warp due to low hot strength of the resin bond. Extra stock must often be added to offset this tendency. Patterns having many vertical planes are more suited to shell molding as the heat is dissipated at a faster rate so casting cooling is accelerated. Figure 1 is an excellent example of an electrical motor housing embodying these features.

Close tolerances are sometimes impossible to consistantly reproduce due to a variety of operating variables. The foundry doing shell molding should be on guard against making promises regarding extremely close dimensions on some designs without making an experimental casting first. Co-operation between the design engineer and the foundryman should result in the elimination of difficult molding features.

Maximum draft on all vertical surfaces which facilitate the stripping of the shell can often be arranged to their mutual benefit. The producibility of holes and slots can be more accurately assured in a casting where ample draft has been provided. Sharp changes in adjoining sections of a casting can be modified to procure more uniform cooling and result in the prevention of warping rejects.

Allowance for a pick-up in dimensions across the parting line can be made on the pattern because the spots of resin glue are sensitive to shell temperature and do not consistantly maintain the same size. The deposit of resin glue should be regulated so as to be 1/4-in. wide at the base and 1/4-in. high. An adequate allowance would be 0.005 in. on the pattern.

Patterns

When only short runs are planned, aluminum patterns will suffice. However, they must be free of porosity or they quickly become scored from the abrasive action of the sand in the ejection operation. Aluminum patterns are inclined to be stickier than brass or iron patterns so a more generous application of the mold release solution is recommended. Silicone emulsions with water dilutions are the most effective parting agents and safer than the solvent types which ignite and allow a carbonaceous residue to accumulate on the patterns.

Figure 2 shows a plywood investment box and an inexpensive pattern plate for trial castings. In this way the expected tolerances and finish can be readily ascertained prior to the construction of the production pattern.

Patterns must be designed to allow for mold ejection pins. The use of broader carriage-bolt type heads on ejection pins will reduce the number of pins required to lift a shell. It's a good rule to install one push-pin for every 20 sq. in. of shell.

Cylindrical shaped cast iron bushings work better than steel springs that lose their resiliency from repeated heatings. A push-pin bushing should have a 7/8-in. diameter and a 3/4-in. height, with a 13/32-in. hole provided in its center.

For quicker registering of shell molds in the bonding machines, three locating prints make for more efficient alignment of the cope and drag than the usual four.

Sand Mixing

Any style sand mixer seems to work well in shell molding. A five-gallon drum with three angle iron cleats is depicted in Fig. 3. The beginner can experiment with a make-shift mixer such as this before deciding what equipment would suit his operation best.

Dry mixing of shell mold resin and sand is best achieved in a hermetically sealed mixer to prevent any loss of the expensive resin to the atmosphere. To act as a dust suppressant and also prevent resin segregation, 0.2 per cent kerosene should be sprayed into the mix before the mulling cycle begins.

When silica sand is employed the broadest grain distribution should be maintained to minimize expansion. A seven screen spread with no more than 25 per cent on the highest peak is strongly recommended. Low melting point buffers should be added to augment wide grain distribution. Wood flour or carbonized cellulose in increments of 2 per cent (not more) function very well. Typical grain distribution with the desirable percentages is shown in Figure 4.

The choice of sand in ferrous practice is related to casting thickness—sands of No. 130 fineness for small castings and No. 90 for large castings. Resin content in dry-mixing should be 6 per cent with 0.2 per cent kerosene.

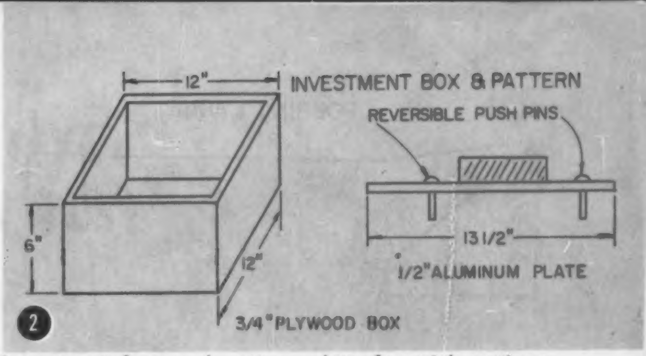
Defects

Resin strengths sometimes vary at elevated temperatures. This is partly due to certain hard-to-control factors in batch mixing. The shell mold operator is advised to blend several resins to avoid any substandard property from developing in his dry mixture.

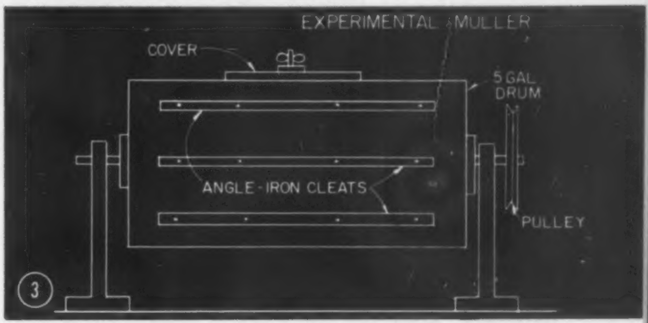
Shell mold cracking from thermal shock can be attributed to sand expansion and the limited hot-strength of phenolic resin binders. Another contributing factor is the tendency of resin to separate from the sand in the mulling and investment operation.

Expansion troubles may be eliminated by replacing silica sand with the more thermally stable minerals such as zirconite, forsterite and mullite of equal fineness. Precoating with resin by hot mixing also helps. These materials add considerably to the unit price of the casting but give superlative finish and extremely close dimensional accuracy as a premium.

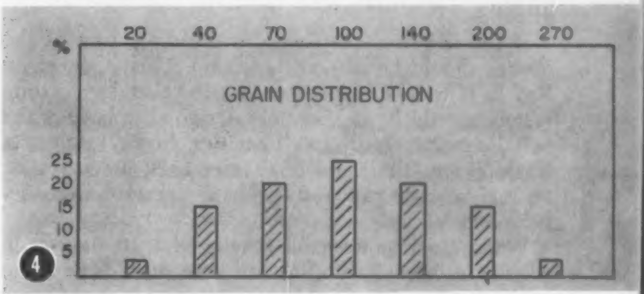
A common problem in shell molding is penetration due to resin segregation. This is mainly visited on the relatively small castings. The installation of a vibrator on the pattern plate or carriage while the shell is in the investment position will insure a more dense packed mold. The incorporation of 0.75 per



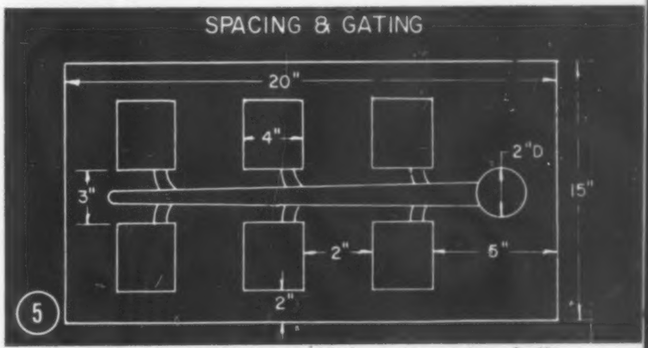
Investment box and pattern plate for trial castings.



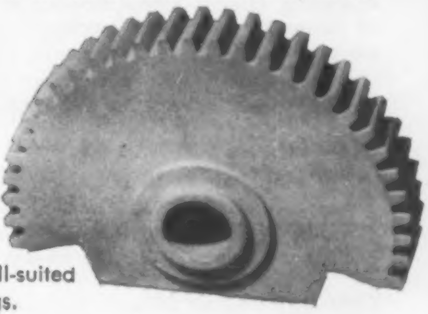
Make-shift muller used for shell mold experiments.



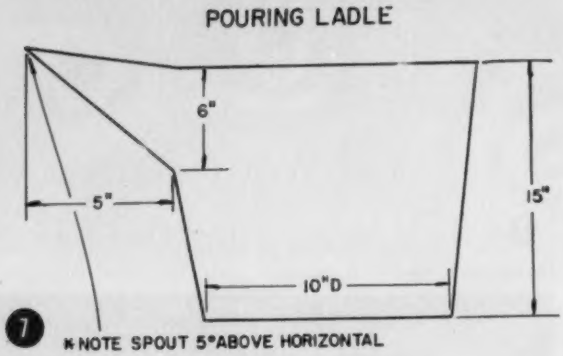
Typical grain distribution with desired percentages.



Good spacing in a 15 in. x 20 in., six cavity shell.



Edge-gating is well-suited to flat-back castings.



cent iron oxide in the mixture will also aid in controlling this defect.

Gating and Risering

The gating and risering of shell mold castings is critical. Many rejected castings are the direct result of gas-scabbing. To hold this type of defect to the minimum, keep the distributing runner on a level plane to avoid any aspiration caused by change of direction.

If the in-gates are placed in the drag, part of the runner should be placed there also. This is shown in Fig. 5. It cannot be overemphasized that the feeding system should be deliberately designed to convey the metal simultaneously to all cavities. In the event of a single cavity the same flow from each in-gate must be regulated to prevent any back pressure from developing.

When castings demand risering due to their bulk or composition, it is often advantageous to use some form of edge-gating technique. Edge-gating is especially suited to flat-back castings such as the spur gear in Fig. 6. Overlapping the in-gate in the cope by 1/16 in. aids in preventing unsightly grinding marks and promotes easier break-off in the subsequent cleaning operations.

When any doubt exists regarding the flow-pattern of a feeding system in a multi-cavity arrangement, it can be predetermined by cutting out the intended design in a block of sculptor's clay and pouring some liquid until the desired results are obtained.

Figure 5 illustrates good spacing in a 15 in. x 20 in. shell with a six cavity arrangement. Note the curved in-gates from the central runner bar which is progressively reduced in area to deliver the metal with minimum turbulence and fill each cavity simultaneously. Here is a shell molding application of some of the gating principles developed by AFS sponsored research at the Battelle Memorial Institute. Back gas from the combustible resin binder cannot be tolerated in the mold or gas scabs will result.

Pouring Practices

The employment of a strainer core in the feeding system is cheap insurance. This is advised because it protects the shell mold from the entrance of slag and extraneous material. A good stream is developed for

Continued on page 136

1959 CASTINGS CONGRESS PAPERS

■ The technical articles appearing in this preview section of Modern Castings are the official 1959 AFS Castings Congress papers—the most authoritative technical information available to the metalcasting industry.

Nearly 100 technical papers presented at the 63d Castings Congress of the American Foundrymen's Society will be printed here prior to publication of the complete 1959 AFS Transactions.

■ Written discussion of these papers is welcomed and will be included in the 1959 Transactions if submitted by September 1. Discussions should be addressed to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

■ The complete case-bound volume of 1959 AFS Transactions, including all papers and all discussion, will be published December 1. Orders for this volume should be addressed to the Technical Department.

INTRODUCTION OF TENTATIVE HOT SHELL DEFORMATION TEST

Report of AFS Sand Div., Shell Mold and Core Committee 8-N prepared by Roderick J. Cowles

ABSTRACT

Literature references are cited which establish that instrumentation and test methods have been developed to evaluate the deformation changes which occur near the surface of conventionally formed mold walls subjected to molten metal. According to these references, these "hot deformation" data have been correlated with the quality of cast surfaces produced by molds of duplicate composition. The results are a guide to the selection of molding materials, molding methods and casting design to develop optimum castings.

Recent surveys and experimental studies conducted by AFS Committee 8-N have emphasized the importance of mold wall movement and shell cracking caused by molten metal poured into shell molds. Production of optimum surface shell molded castings evidently depends considerably upon a knowledge of the hot deformation characteristics of shell mold compositions, just as it has for conventional molds.

Initial results have shown the value of a new test method which applies heat at a rapid rate to one side of shell mold specimens simultaneously loaded transversely. Changes in deflection, conditions of break and rapid deformation are correlated with time, temperature and load application. There is an initial movement towards the heat application in opposition to the load, followed by a sagging between supports in the direction of and proportional to the load. Thermal expansion of the refractory grains differentially heated on one side of the specimen is the reason for the arching against the load. There is a similar occurrence in actual casting practice.

An analysis of initial test data indicates that variables in the shell mold product such as mold wall thickness; refractory grain composition; size, size distribution and configuration of the grain; type and quantity of phenolic binder applied as a powder mix or as a precoat on the refractory grain; degree of cure and the effect of additives will all require consideration in correlating hot deformation results with quality of casting surfaces. This information has been used as a guide for establishing tentative standard equipment and test methods for controlling hot deformation in production, and as a tool for research studies of shell molds.

INTRODUCTION

The improvement of casting quality related to the requirements of performance and appearance is a never ending objective of the foundry technologist. An important phase of this promotion for better castings has been the increase in development studies to determine what occurs at the mold surface, and the refractory binder structure behind the surface, when hot molten metal is poured and cooled to solidification against the mold wall.

Numerous studies and reports[1,2,3,4,5,6] supported by reliable data have assisted in clarifying the causes of "rattails," "buckles," "scabs," "veining" and "cuts and washes," which are the result of mold changes when subjected to high temperatures of molten metal. The knowledge obtained through instrumentation in such studies has been and will continue to be valuable for alleviating these problems in foundry practice.

Free expansion of the mold composition with temperature changes; variations in mold strength properties with gradient heating and isothermal heating; dimensional deformations developed as stress-strain data and expressed as modulus of elasticity; hot deformation data[2] correlated in such factors as "hot deformation rate" and "hot toughness" have all contributed to determine improvements in molding materials and casting design which minimize the problems associated with high temperature at the mold wall.

These studies have all been applied to conventional green sand and dry sand molds with little attention to the basically different sand-phenolic resin shell molds. A recent shell molding survey conducted by 8-N Committee[7] emphasized that more problems of shell production, such as mold cracking and surface defects, could be attributed to mold-wall movement and thermal shock as the shell is subjected to the hot molten metal, than any other cause for scrap castings. Simultaneous with this survey, an experimental "Study of High Temperature Properties of Shell Molds"[8] was carried out.

The results again showed the need for more knowledge of the changes in the shell mold structure when subjected to molten metal conditions. The high temperature shell expansion information obtained in this study[8] showed the value of such test data in correlating casting defects with the shell mold properties.

The committee members further responded with a preliminary evaluation of instrumentation, test methods and demonstrated data, in order to establish a Tentative Hot Shell Deformation Test. This

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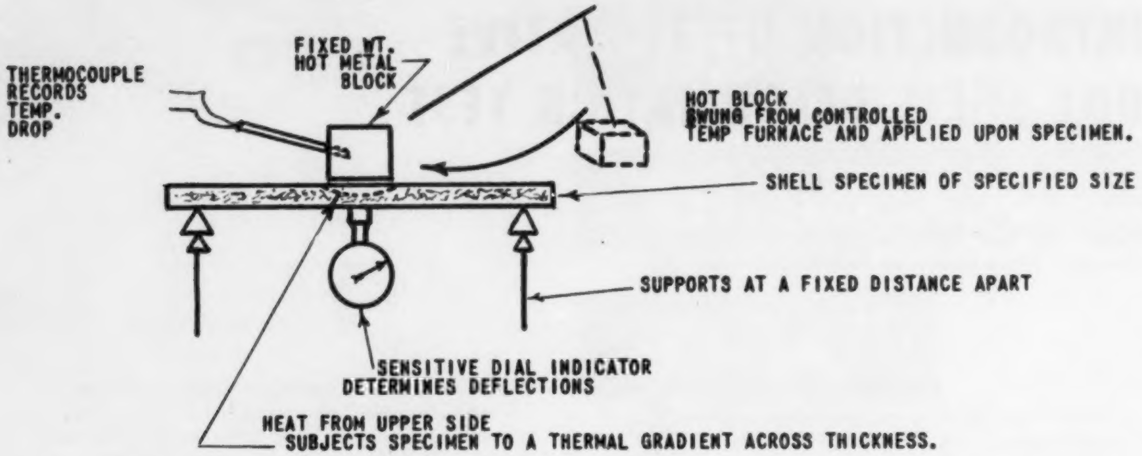


Fig. 1 — Principle of operation of instruments A and B for hot shell deformation evaluation. Data are charted as dimensional deflections with changes in temperature (instrument A) or time (instrument B). The variables of the test to be either fixed or recorded are 1) weight of metal block, 2) area of block adjacent to specimen, 3) temperature of block when applied to specimen, 4) dimensional deflections with drop in temperature of heat block (instrument A) or with time of heat application (instrument B), 5) rate of heat conductivity (a time-temperature relationship), 6) thickness and width of shell mold specimen, and 7) distance between supports.

test is developed as one possible source of data which can be correlated with shell mold composition and structure, guiding the elimination of casting imperfections.

The test is designed to show hot deformation similar with the actual occurrence of molten metal heat applied to one side of a cold shell mold wall. This is more representative of actual casting conditions, and provides additional information to that obtained by the conventional free expansion of heated cylindrical specimens.

TEST METHODS STUDY FOR DETERMINING SHELL MOLD THERMAL PROPERTIES

At least five different manufacturing organizations with representatives on Committee 8-N, submitted hot deformation data for shell mold specimens obtained by testing three resin coated sands. The coated sands were prepared at one source, properly sampled and distributed for individual evaluation. No particular testing equipment or method of test was designated for determining data pertaining to hot shell deformation.

The results were fundamentally alike, and established certain characteristics of shell deformation due to high temperature heat applied to one side of a precured shell specimen.

Three of the test instruments, the principle of their operation and the representative charts of data determined by these tests, are used here to portray this general approach to hot deformation evaluation of shell molds. Figures 3, 4 and 5 show the three instruments considered and are designated respectively as A, B and C. The principles of their operation are diagrammatically given in Figs. 1 and 2, and their data represented in the charts of Figs. 6 and 7.

In every test the shell specimen deformation is initially in opposition to the heated metal block and to the direction of applied load. In all cases the specimens were 1 in. wide and ¼-in. in thickness, with

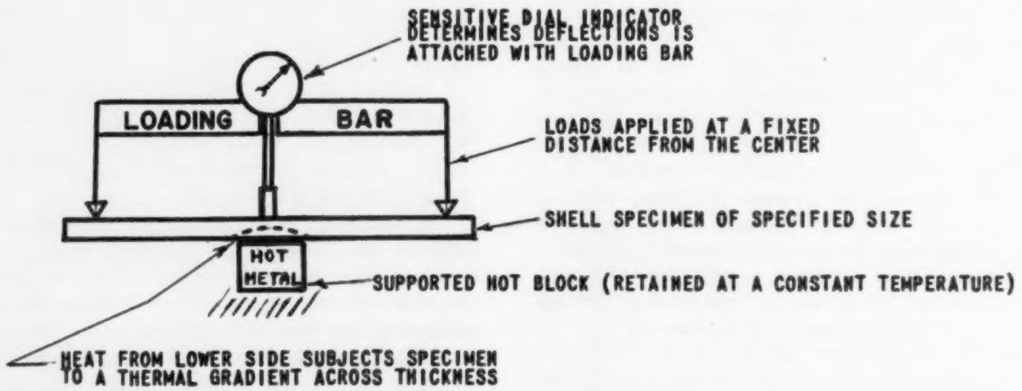
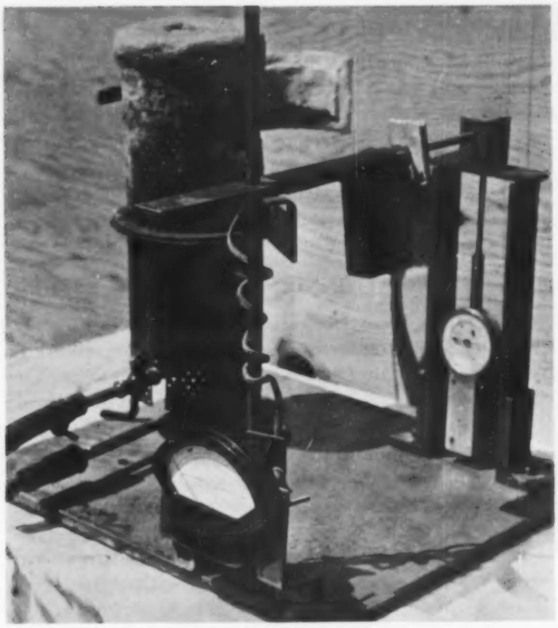
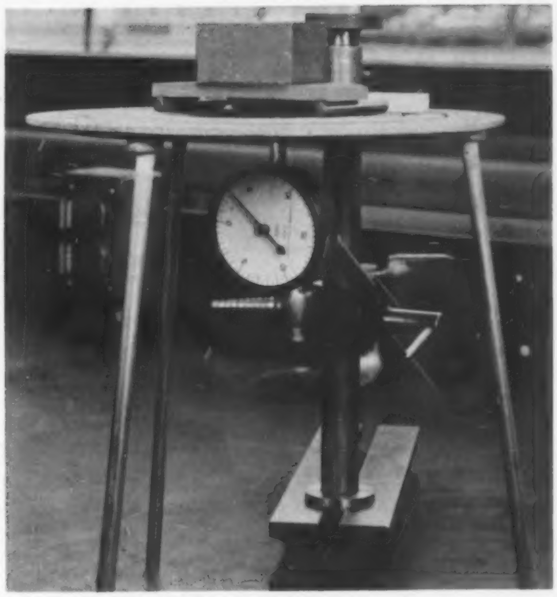
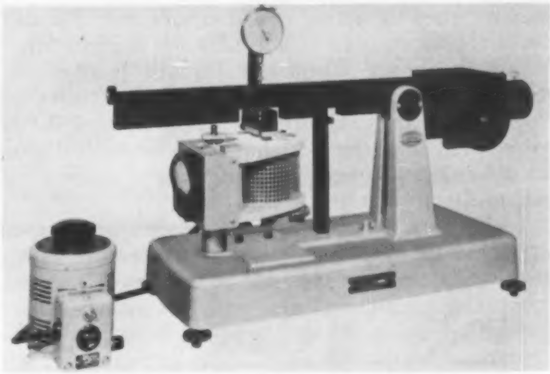


Fig. 2 — Principle of operation of instrument C for hot shell deformation evaluation. Data are charted as dimensional deflections with time of heat application. Variables of the test are 1) weight of load applied, 2) area of block adjacent to specimen, 3) temperature of block when applied to specimen, 4) dimensional deflections with time of heat application, 5) rate of heat conductivity (a time-temperature relationship), 6) thickness and width of shell mold specimen, and 7) distance between supports.







Figs. 3, 4 and 5 — The three test instruments considered for the hot shell deformation evaluation test for which their operation principles are given in Figs. 1 and 2. Figure 3 (above), instrument *A*. Figure 4, (upper right), instrument *B*. Figure 5, (right) instrument C. Data charts for these instruments are given in Figs. 6 and 7.

distances between supports varying between 3 to 3.375 in. and loads from 258 grams to 1.5 lb. This arching of the sample toward the heated side disregarding the opposing load stress is generally explained as an expansion of the sand grains as they are heated. The heat conductivity through the sand and resin bonded structure is slow enough to cause selective expansion of the grains first subjected to the high temperatures.

The size of grains, their configuration, their degree of packing and the intrinsic property of thermal coefficient of expansion for the refractory grain in use is expected to vary the degree of this movement for any specified conditions of test. In every case studied, there was an initial expansion of the heated side.

As the specimen reaches a uniform temperature the refractory grains become uniformly expanded and the resin binder is weakened by thermal effects. This results in a load response causing the specimen to sag down between the supports. The distance of movement related to time will vary according to 1) the load applied, 2) the total heat transmitted to the sample, 3) the rate of heat transmittal, 4) the variables of the refractory such as its coefficient of thermal expansion, size, size distribution, and grain configuration, 5) heat flow properties of the resin binder, 6) the degree of resin cure, 7) the quantity of resin used, 8) degree and rate of resin degradation with heat application, and 9) the effect of any additives or included foreign materials.

This interrelation of multiple variables always increases the problem of evaluation and complicates the correlation of test data with use results. This hot deformation test is another valuable tool for providing data which can be used with other test information to better unravel and predict the variations in casting product quality with the materials and fabrication methods used to produce the shell molds.

EXAMPLE OF HOT DEFORMATION STUDIES

The constructive criticism of any evaluation method is best developed by experience in production and development application. Instrument *A* has been in use for more than 6 years as a shell molding production control tool. Instrument *C* is a later modification, which allows improved precision and greater flexibility of test for research studies. Figure 7 is a chart to demonstrate the value of data obtained with instrument *A*. This is a plot of dimensional deformation changes with drop in temperature of the heating block. This is a time dependent variable and is better correlated by instrument *C* where the temperature is retained constant and the deformation plotted against time of heat application.

The general differences shown in Fig. 7, however, are quite adequate to analyze differences in shell performance. There are, of course, different evaluation objectives when pouring bronze compared with steel as well as considering differences in casting sizes and configurations.

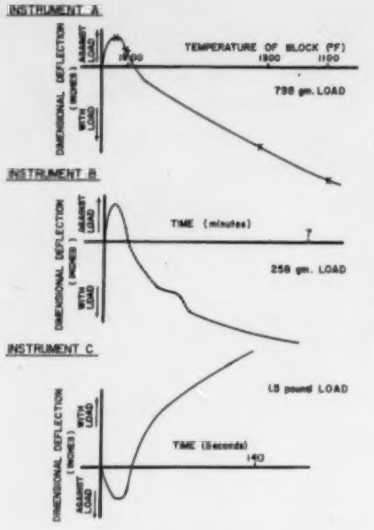


Fig. 6 — Representative data charts for instruments A, B and C for hot shell deformation evaluation.

The *A-3* sand resin combination is low in hot rigidity and will probably not hold dimension, especially when undercured as in sample *A-3*. *B-6* and *C-6* are both considered adequate for medium sized bronze casting in adequately planned (gating and risering) shell molds. Evidently, a certain degree of cure is necessary to contribute hot strength to the *B* coated sand since the *B-3* samples are broken early in the deformation rather than continuing to support the load during further heat application.

Results such as *C-6* may be approaching a strength rigidity under conditions of heat which cause cracking in the mold and hot tears in the castings. These test

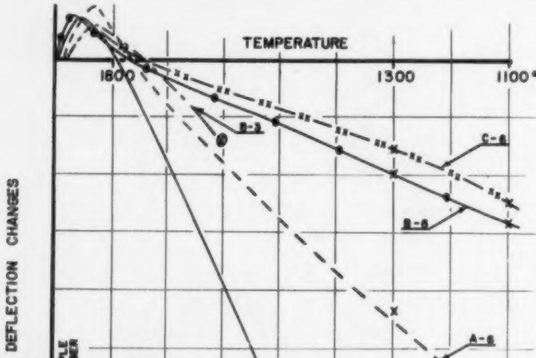


Fig. 7 — Plot showing variations of deformations due to differences in shell specimens. Data for this graph obtained with instrument A.

data together with tensile strength, transverse strength, free expansion data, bulk density of the molding composition and the knowledge that this is a round grain sand which is more easily close packed, can be analyzed in relation to actual shell performance. The effect of selected additives or changes in refractory grain composition on the hot deformation results, plotted for analysis as in Fig. 7, will establish the value of this test for obviating such problems as mold cracking and hot tears.

HOT DEFORMATION TEST POTENTIAL VALUE

The value of extending this fundamental test instrument for research studies becomes apparent. Instrument *C* can be used in numerous ways. The applied weight can be kept low during the first 15 sec of heat application to emphasize sensitive differences in the refractory grain expansion with heat. Following this movement, which opposes the load application, an increase in applied weight would best determine hot shell rigidity and strength.

The heat deformation of equal samples under different loads would provide data for calculating elastic modulus, and with rupture data a factor such as hot toughness of the shell can be determined. These approaches can be studied under various isothermal conditions to further extend the knowledge of pouring metals of different solidification temperatures into shell molds.

The thickness of the shell, and the manner of supporting the shell during casting, will further determine the relative importance of initial refractory grain expansion and subsequent hot sag deformation.

SUMMARY OBJECTIVE

This is not a report of completed development studies in hot deformation of shell molds, but rather an introduction of a valuable testing tool for studying such production problems as shell cracking and hot tearing of castings. Committee 8-N is presenting a tentative test based on these introductory instruments, methods and data examples. Further refinements and knowledge of the test will develop as use experience is correlated with committee work, with outside research studies and with individual publications.

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Mn-V-Mo AGE-HARDENING AUSTENITIC STEEL

foundry characteristics

By N. C. Howells and E. A. Lange

ABSTRACT

Successful founding of the new Mn-V-Mo age-hardenable austenitic steels depends upon the use of special techniques with regard to melting, pouring, mold materials and heat treatment. Melting procedures for minimizing hydrogen content of the molten metal and principles of gating design are described. Sand mixtures with a zircon sand base, containing 5 per cent silica sand and 1 per cent core oil as special additives, promote high quality casting surfaces. Tensile properties of the metal can be controlled by the aging phase of the heat treatment; 145,000 psi tensile strength, 110,000 psi yield strength and 12 per cent elongation are attained with an aging treatment of 8 hr at 1300 F.

INTRODUCTION

Widespread use of conventional nonmagnetic casting alloys aboard minesweepers is precluded by their cost, limited mechanical properties or in some cases their physical properties. In order to more extensively utilize the economical and versatile casting process for producing complex shapes, naval engineers require an austenitic steel with a yield strength in the range of 100,000 psi.

The initial phase of an investigation, aimed at developing austenitic steels with high-strength properties, was concerned with the adaptability of recently developed wrought alloys to the casting process.[1] Two wrought alloys were successfully cast and heat treated to high strength levels, but both of the alloys utilized nickel as a primary stabilizer for the austenitic structure. A new family of austenitic alloys containing a minimum amount of nickel was subsequently developed for the purpose of providing a material for emergency conditions requiring conservation of nickel.

The new alloys are essentially manganese stabilized, austenitic steels with age-hardening characteristics promoted by vanadium and molybdenum. Alloys in the composition range 0-2.5% Cr; 14-18% Mn; 0.25-0.60% C; 0.25-0.7% V and 0.4-3.5% Mo can be age-hardened to the range 250 to 500 Bhn and remain nonmagnetic (permeability less than 1.2). Although the manganese content of these alloys is only slightly higher than the manganese content of Hadfield steel, the age-hardenable alloys have much lower carbon contents, and special foundry techniques are required to obtain sound castings with good surface finish.

The heat treatment for the new alloys is also more involved than the heat treatment for Hadfield steels. The development of effective foundry techniques for producing sound castings with good surface finish, and the effects of time and temperature during the aging phase of the heat treatment on the tensile properties of an alloy with a nominal composition, are detailed in this report.

CASTING CHARACTERISTICS

Melting and Pouring

In melting Mn-V-Mo alloys, the first consideration should be given to the fact that steels with 14 per cent manganese are effectively deoxidized because of the high amount of manganese. It has been established that deoxidized or killed heats have a greater affinity for hydrogen than an unkilled heat.[2,3] Reference is made to experimental work with acid open hearth melting where the hydrogen content of the steel increased 1 to 3 ppm in a few minutes after blocking the heat. This situation is not analogous to the induction melting used here, but, in a qualitative sense, caution in the handling of fully killed steels is definitely indicated.

Table 1 contains the list of charge materials and Table 2 the log for a typical heat. The steel was melted in a high-frequency 350 lb induction furnace, and about 1½ hr were required to bring the metal to pouring conditions. Dry argon gas was piped through a loosely fitted cover into the crucible at a rate of flow generous enough to maintain a substantial amount of argon in the furnace atmosphere. A carbon boil was produced just prior to adding the alloy elements to purge hydrogen in the initial-charge armco iron.

A vigorous boil was maintained for several minutes by adding 0.10 to 0.15 per cent carbon, and allowing it to react to about 0.03 per cent carbon. An addition of ferrosilicon was then used to kill the boil. Although the inert gas atmosphere was maintained primarily to minimize hydrogen pickup, it also reduced the manganese loss, which was 17 per cent without the

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TABLE 1 — LIST OF MATERIALS FOR A 300-LB MELT

Alloy	Weight lb	oz
Armco iron (0.03% C, 0.01% Si)	231½	
Ferrosilicon (50% Si, 50% Fe)	1	13
Regular ferromanganese (6.7% C, 80% Mn, 13% Fe)	12	8
Electrolytic manganese	39½	
Nickel	9	0
Ferromolybdenum (59% Mo, 41% Fe)	10	4
Ferrovanadium (53% V, 46% Fe)	3	8

TABLE 2 — HEAT LOG FOR 300-LB MELT

Time, pm	Action
1:00	Furnace turned on. Charge of nickel plus armco iron, 90-kw power, "low" tap.
1:20	Furnace changed to "next to low" tap. Inert gas introduced into furnace (argon).
1:35	Furnace changed to "next to high" tap.
1:45	Furnace changed to "high" tap.
2:15	Slag removed from metal. Inert gas turned off.
2:15	Carbon boil caused by adding about 0.15% carbon and boiling away carbon to 0.03%.
2:20	Ferrosilicon added. Ferromanganese and the electrolytic manganese added.
2:25	Ferromolybdenum added, followed by ferrovanadium.
2:25	Protective slag cover added. Inert gas (argon) reintroduced into furnace.
2:35	Metal tapped into ladle at 2900 F. Molds poured.

protective atmosphere and 13 per cent with the protective atmosphere. Following the alloy additions, a basic slag cover was maintained on the metal in order to minimize heat loss and gas pickup.

The metal was tapped at 2900 F into a preheated teapot ladle, and the castings were poured at 2800 F. Figure 1 gives a general view of the gating system used for the castings in these experiments. The principle features of the gating system are the choke at the sprue base for controlling the mass flow rate (lb/sec), an enlarged runner bar for limiting the linear flow rate (in./sec) and an ingate entering the riser. Both the sprue and the ingate are larger in cross-section than the choke. The dimensions of the gating system were as follows:

Part	Area (sq in.)	Ratio to Choke Area
Choke	9/16	1
Sprue	11/16	1.2:1
Ingate	13/16	1.45:1
Runner Bar	1¾	3:1

Fig. 1 — View of 4 x 6 x 1 in. plate with riser and gating used for tensile property and surface quality experiments.

The total casting weight was about 25 lb and required a pouring time of 7½ sec. This represented a flow rate of 3.3 lb/sec on a weight basis, or 12 cu in./sec on a volume basis. The average linear flow of the metal through the runner was calculated to be 7 in./sec. Since the enlarged portion of the runner bar was 4½ in. long, the metal was in this portion of the gate a little more than ½ sec. It was found that a flow for this length of time within the runner bar is effective for trapping incidental slag which has entered the sprue with the molten steel.

Mold Materials

Initially, sand mixtures for molds for the new Mn-V-Mo steel were patterned after conventional sand mixtures for Hadfield steel, i.e., silica sand containing additives to provide for a reducing atmosphere. However, severe mold-metal reaction occurred when the Mn-V-Mo steel was poured into molds of sand containing such additives as core oil, seacoal, graphite, pitch and cereal. The increased mold reactivity of the Mn-V-Mo steel was attributed to its higher manganese content and its lower carbon content, which necessitated a higher pouring temperature.

Zircon sand was then used, and while no mold-metal reaction occurred with this more refractory material, a lap type of defect was formed, as illustrated in Fig. 2. The laps were apparently caused by a tenacious manganese oxide film which formed on the surface of the molten metal and restrained the flow momentarily, forming a defect with a cold-shut appearance. After 1 per cent core oil was added to the zircon sand to provide a reducing atmosphere, the surface laps generally disappeared (Fig. 3).

A consistent, protective environment is difficult to achieve with atmospheric casting, and the lap defect occasionally recurred. A small amount of silica sand was then added to the zircon base sand with the aim of decreasing the surface tension of the oxide film. It turned out that an addition of 5 per cent silica sand was sufficient to consistently eliminate the lap defect (Fig. 4). When higher percentages of silica sand were used (10 to 15 per cent), the mold-metal reaction was sufficient to cause a rough surface. The silica portion of the mold material was also incorporated

Fig. 2 — Lap type of defect formed on plate casting when sand of the following composition was used; 100 lb 140-mesh zircon sand, 0.5 lb western bentonite, 1.5 lb southern bentonite, 0.5 lb corn flour and 2.1 per cent moisture before baking.

Fig. 3 — Surface laps generally disappeared from plate casting when sand of the following mixture was used; 100 lb 140-mesh zircon sand, 1 lb core oil, 0.5 lb western bentonite, 1.5 lb southern bentonite, 0.5 lb corn flour and 2 per cent moisture before baking.

Fig. 4 — The surface lap defect was consistently eliminated from plate casting when sand of the following mixture was used; 95 lb 140-mesh zircon sand, 5 lb silica sand (no. 80), 1 lb core oil, 0.5 lb western bentonite, 1.5 lb southern bentonite, 0.5 lb corn flour and 2.2 per cent moisture before baking.

in a wash rather than throughout the body of the mold material.

A higher percentage (10 per cent) of silica could be used in the wash to make it more reactive and still achieve a smooth casting surface, because a limited amount of silica was available. The surface quality obtained from a zircon sand mold containing 1 per cent core oil, and coated with wash containing 90 per cent zircon flour and 10 per cent silica flour, is illustrated in Fig. 5.

Risering

The production of sound castings free from shrinkage involves two prime considerations:

1) The proper size of riser, which means that there must be sufficient molten metal stored within the riser to furnish feed metal to compensate for shrinkage.
2) Temperature gradients must be such that a continuous channel is maintained from the riser to the advancing front of completely solid metal throughout the solidification period.

Although the research on the shrinkage of this steel is limited, the results of one series of experiments with a plate 4 x 6 x 1 in. can be used as a guide. Using the Naval Research Laboratory formula which had been developed for Class B steel,[4] the upper limit for the riser volume was a 2½-in. riser 2¼ in. high. However, when a 2½-in riser was used and poured to a 6-in. height, shrinkage was evident in the casting. A 3-in. diameter riser resulted in a borderline case, some castings exhibiting shrinkage and some not. In actuality, the feeding distance may have been too long for this composition.

HEAT TREATMENT AND TENSILE PROPERTIES

The feeding distance was 4 in., which is 4 times the thickness T of the plate. The specified feeding distance for the Class B steel is 4½xT, or 4½ in. for a 1-in. thick plate.[5] Thus, it appears that this alloy is more difficult to feed than the Class B steel, and consequent precautions should be taken.

The heat-treating procedure for hardening these steels in its basic form resembles that for the majority of age-hardening alloys. The metal is first solution treated at a high temperature in order to dissolve the hardening phase into the matrix. When this is accomplished, the metal is quenched to produce a supersaturated condition. An aging treatment at some intermediate temperature then produces the hardening by reprecipitating the hardening phase. The cooling rate from the aging temperature is not critical, and air cooling is generally satisfactory.

Thus, the Mn-V-Mo alloys differ from low-alloy steels, since alloy steels are softest after quenching from the solution temperature and hardest after heating to what is ordinarily considered to be a high tempering temperature. This investigation was primarily concerned with the aging treatment, because the balance between high yield strength and ductility is primarily controlled by the aging treatment. A few preliminary tests to establish the solution treatment had shown that no appreciable benefits could be derived with long holding periods at 2100 F, so all specimens were held for 1 hr at 2100 F and quenched in water.

Figure 6 is a graph of hardness versus aging time for a Mn-V-Mo steel with the nominal composition. The relative positions of the curves for the three temperatures in Fig. 6 are basically similar for the vast majority of the hardness curves that were ob-

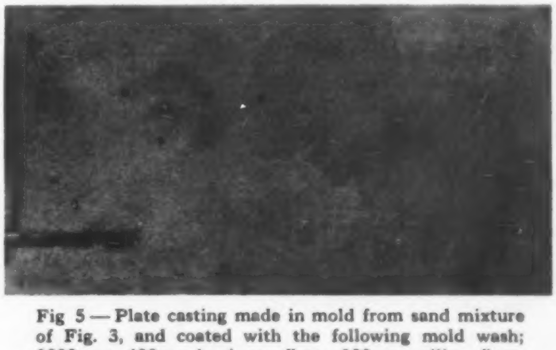

Fig 5 — Plate casting made in mold from sand mixture of Fig. 3, and coated with the following mold wash; 2000 gm 400-mesh zircon flour, 200 gm silica flour, 37.5 gm western bentonite, 20 gm dextrin plus water to thin.

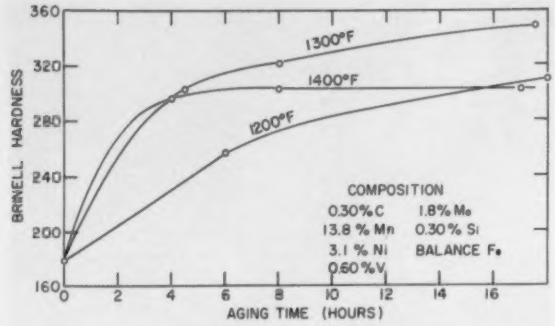

Fig. 6 — (left) — Time and temperature during aging treatment effect on hardness of a precipitation hardening austenitic steel.

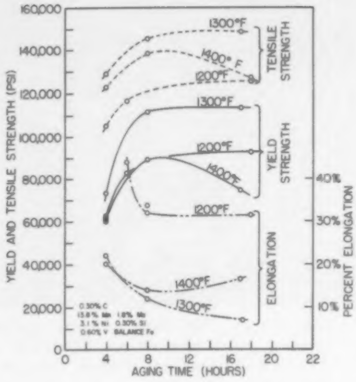

Fig. 7 — (right) — Aging conditions influence on tensile properties of a precipitation-hardening austenitic steel.

tained for steels with other compositions. However, the maximum hardness attainable with a standardized solution and aging treatment is strongly influenced by the composition, most of all by the carbon, slightly less by the vanadium and to a lesser degree by the molybdenum.

Aging Treatment Effect

The influence of the aging treatment on the tensile properties is shown in Fig. 7. The pattern of the tensile properties follows that of the hardness curves, that is, the 1300 F tensile and yield strength curves reach the highest values; the 1400 F values are intermediate; and the 1200 F tensile properties gradually increase and exceed the maximum properties attained at 1400 F. From these data aging temperatures between 1200 and 1300 F can be recommended for best control of properties.

However, there is an advantage to using temperatures approaching 1300 F when maximum yield strength is desired, because the maximum yield strength is reached in the shortest time at 1300 F with little danger of overaging. After aging 8 hr at 1300 F, the tensile properties of the sample steel were 145,000 psi tensile strength, 110,000 psi yield strength and 12 per cent elongation. If higher ductility (20 to 30 per cent) is desired, an aging temperature between 1200 and 1250 F is indicated.

The Mn-V age-hardenable austenitic steels are machinable when techniques comparable to those used for the austenitic stainless steels are used, i.e., carbide tools, low speeds and high feed rates. Machine operations should be performed after the casting has been age-hardened. Metal in the as-cast condition can only be cut by abrasive methods, and after solution annealing it has a tendency to load the tool and gall.

SUMMARY

The following foundry process conditions are recommended for melting and casting Mn-V-Mo age-hardening austenitic steel:

1) Minimize hydrogen content by using clean, dry materials, a carbon boil and a dry inert gas atmosphere for induction melting or protective reducing slag for arc melting.
2) Pouring temperatures should be high, 2775 to 2850 F.
3) The gating system should have a runner choke and sufficient runner size to permit the metal to remain in the runner for ½ sec before entering the mold.
4) The following type of sand mixture should be used for molding material:

Sand	Additives (% of sand)
95% Zircon	1% core oil
5% Silica	0.5% western bentonite
	1.5% southern bentonite
	0.5% corn flour
	2.2% water

5) Risers should be slightly larger and feeding distances slightly shorter than those calculated by N.R.L. methods for carbon steel.

The following heat treatment schedule is recommended for hardening Mn-V-Mo age-hardening austenitic steel:

1) Solution anneal 1 hr at 2100 F.
2) Water quench.
3) For maximum yield strength with nominal ductility age harden for 6 hr at 1300 F. For controlled yield strength and high ductility age harden at 1200 to 1250 F.

Castings in the age-hardened condition can be machined with techniques comparable to those for austenitic steels, i.e., carbide tools with slow speeds and heavy feeds.

ACKNOWLEDGMENT

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TIME STUDY AND METHODS TRAINING FOR SUPERVISORS

By John Taylor

ABSTRACT

The need for supervisor education in time study and methods is discussed. A suggested program lasting for six or seven meetings is given.

INTRODUCTION

Time study, motion analysis and incentive systems are valuable management tools. However, for best results they must be properly used. Progressive foundry managements thus have come to realize that such tools will be used most effectively, and the business will profit most when foremen and supervisors are trained to know the real details of motion analysis, time study and the basic principles involved in the application of incentives to the activities they supervise.

Time and again it has been demonstrated that when foremen realize, through training, what can be accomplished by a good motion analysis study, or an activity study on some particular operation, they look for and find other improvements which also can be made.

In addition, foremen who have received proper training relative to the department incentive plans answer the questions of operators and union stewards and prevent dissatisfaction. In being able to answer such questions the prestige of the foreman is increased as well as the workers' respect for him. He then, of course, is in better position to "sell" the system to them. In addition, management benefits from having supervisors trained to use the proper tools for accurate estimating.

SUPERVISOR EDUCATION

Educating supervisors on this subject is neither costly nor time consuming. Usually it is not necessary to take the foreman away from the job for an extended period in order to give him an intensive training on time study and incentives, although this has been done in some of the larger foundries with excellent results. Where such training can be accomplished, the man returns to the job with a broader knowledge of management requirements, plus an inspiration to look for details which ordinarily would not be noticed.

No foreman should be expected to take time studies in his department, but the results of the training will save time for both the time study and personnel departments, and the foreman is more likely to institute methods improvements on his own initiative.

WEEKLY MEETINGS

When it is not possible to provide a training program over an extended period, which frequently is the case, weekly meetings can help to broaden the knowledge of the foreman and enable him to do a much better job. It also will provide a needed stimulant in the attitude toward management in general, and the realization that he is a part of it. Foremen not only are the men on the "front line" but also the logical source for future executives. Therefore, top management can strengthen its position by increasing the knowledge of the supervisory group.

Meetings of approximately one hour's duration can be held each week, either on a general discussion basis or with a qualified leader. In meetings of this kind, too much time should not be spent on fundamental details, but rather on a broad view of the subject.

SUGGESTED PROGRAM

A suggested program, for approximately six or seven meetings might be as follows:

1) Origin of time study; several kinds of incentive systems.
2) Hazards of estimated prices; the necessity for time studies; value of methods analysis; how these subjects are taught in colleges.
3) Recognition of allowances for fatigue, personal, supplemental, balance and incentive; the use of levelling factors and why they were developed.
4) How a time study is made; actually taking one or two simple studies in the meeting room.
5) The use of studies to build standard data; development of constant and variable values; compiling data for operations.
6) Actually setting some time standard by standard data; the many uses of standard data.
7) Checking accuracy of the data by "proof sheets," the completed standard data or "specification sheet."

CONCLUSIONS

Foreman training is essential to the installation and successful use of a new time study, methods or

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incentive program to eliminate delays, misunderstandings and even mistrust of the engineer or the system. These reactions do exist and management should make every possible effort to dispel them and the reasons for them, through a properly planned training program in the fundamentals involved.

People are not skeptical of a good program or of a good tool when properly trained in its use. This is true in all walks of life, and it has been demonstrated that when applied to foundry supervision the problems of time study and incentives diminish or disappear.

DUCTILE IRON CASTINGS VERSUS CARBON STEEL FORGINGS AND WELDMENTS

some comments and recent conversions

By J. L. Salbaing

ABSTRACT

The advantages of ductile iron castings over carbon steel forgings and weldments from the viewpoint of metal structure, isotropy and directionality, strength and production are considered. Case histories of parts which were made by the former processes and converted to ductile iron castings are given.

INTRODUCTION

Product designers and purchasing agents are confronted daily with the proper selection of the most economical and most efficient metal shaping and fabricating methods. Much has been said or written on this subject during recent years, as evidence seems to point out that the foundry industry has been placed in a defensive position. Few foundrymen will disagree with a comment made recently in a trade magazine by Norman F. Hindle:

> "The foundry industry points with pride to the fact that casting is probably the most ancient (and possibly the most economical) method of metal shaping. Let us not forget that the same makes it the most vulnerable to loss of market by new methods of metal forming."

The promoters of these more recently developed methods have used aggressive tactics to penetrate the foundry's market. Using diversified means and constant efforts, they succeeded in striking the minds of the people responsible for the design and production of component parts.

The discovery of ductile iron in 1943 was the first major advance in ferrous metallurgy since Boyden made blackheart malleable iron. Magnesium bearing irons have helped foundrymen reverse the trend towards carbon steel forgings and carbon steel weldments. Whether used in conjunction with sand molding, or newer molding techniques, ductile irons lend themselves perfectly to the production of a number of component parts of high strength and quality at lower finished cost. Ductile iron castings are replacing an increasing number of parts previously made as forgings or weldments.

First, a comparative discussion of ductile iron casting, carbon steel forging and carbon steel weldments from metallurgical, structural and production standpoints, then, a series of examples showing the actual benefits derived when a part was cast in ductile iron will be presented.

DUCTILE IRON CASTINGS VS. FORGED AND WELDED PARTS

No attempt will be made to cover all respective advantages or disadvantages of any of the three fabricating methods. This discussion will be as a reminder of some fundamental considerations, the knowledge of which might encourage the foundryman to carry on his "sales efforts" successfully.

Metal Structures

Wrought products are said to be affected to a lesser extent by metal impurities than castings. Looking at the solidifying process of a liquid metal, of any alloy composition, we see that impurities present in the melt having a lower freezing temperature than that of the base metal solidify last. The greatest portion of the melt being already solid, these impurities are forced between the solid crystals where they turn from liquid to solid. In general, they are nonmetallic and brittle. If the casting thus obtained is stressed, these inclusions usually would be the initiating point of rupture in the material.

The various working processes to which a wrought metal is subjected from its original form as ingot or billet, will tend to break up the continuity or the size of these brittle inclusions present at the base metal grain boundaries.

Theoretically, a wrought shape should exhibit a superior ductility along the main axis of forming. However, the validity of such an influence depends upon many factors. Most important among these would be the presence of impurities and the extent of their deposits. A metallurgically clean cast metal would certainly eliminate most of these disadvantages, and foundrymen possess in the magnesium bearing irons a series of metallurgically clean metals. In order to consistently obtain a structure where the graphite is in a true spheroidal shape, the base metal composition should be maintained within rigid limits. Elements such as antimony, arsenic and bismuth, or metallics such as selenium, tin and titanium are not tolerated beyond certain maxima.

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In addition to the metal purity derived from the selection of furnace charge raw materials to melt the ductile iron base metal, the precise and particular molding techniques required to cast ductile iron play their part. The gating systems should be designed with care to eliminate dross or slag inclusions in the mold. They also should provide a minimum of turbulence in the rapid flow necessary to fill the mold quickly. A 1000-lb casting should be poured in approximately 20 sec, while a 10,000-lb casting should be poured in a maximum time of 65 sec. These requirements oblige the foundryman to use the best known practices in gating the molds. Surface defects will show unless the molding sand is prepared properly.

The above requirements in quality of raw material and care of molding operations, without which a true and generalized spheroidal graphite structure could not be formed, decrease the advantages of the wrought metal for structural applications.

Isotropy and Directionality

The theory of elasticity is the basic concept upon which the knowledge of strength of materials is built. The many formulas used every day for the structural analysis of machine tools, engine parts or other structures, are a direct derivation from this principle. However, the basic hypothesis upon which its validity lies is seldom questioned: Is the material homogeneous and isotropic? Or, in other words, what assurance has the designer that the stresses developed on a plane perpendicular to the direction of the applied force will remain the same when the force is rotated to any other direction? If the member being analyzed possesses this property, its actual performance under static loadings will be approaching that established by calculations.

The goal of foundrymen is to obtain castings exhibiting such a structure. It is recognized that the process of casting is, among all other methods, the one most likely to achieve this required equi-directional structure through the minimum amount of operations. Obstacles lie in the way, however. Foundrymen must succeed in regulating the cooling rate of the liquid metal in the mold so that the crystalline structure will be independent of the metal section. Foundrymen must also use specific techniques to eliminate the unknown thermal stresses remaining within the casting after it has reached room temperature.

In recent years new molding methods have been developed to enable foundrymen to achieve this goal. Progressive solidification is a well understood phenomenon, and casting designs are modified frequently to permit it. The undesirable residual stresses are progressively eliminated either through changes in the design or through molding technique and heat treatment.

It has been stated that if foundrymen are capable of pouring a casting so as to reach progressive solidification, prevent hot spots and use clean metal and procedures, they may obtain a crystalline structure, uniform, homogeneous and entirely satisfactory for all purposes.

In recent years developments in strength of materials have focused the importance of such factors as the stress raisers on the ability of a structure to resist the applied loads in a predictable manner. Surface imperfections and abrupt changes in section thicknesses create points or areas where the stresses developed are seldom predictable in both intensity and direction by means of the normal methods of structural analysis. However, one fact is certain—the more homogeneous and isotropic the material is, the less chance for these stresses to develop and reach, in some directions, values beyond the material's ultimate strength.

It is then clear that materials exhibiting directionality in their properties, as unavoidably all wrought materials do, will be more susceptible to the stress raisers effects. The importance of directionality is, in the author's opinion, too often neglected. It is not uncommon to see gears being cut on a production basis from a steel plate. This is hardly justified from a structural standpoint, since the mechanical properties will vary from one tooth to the other.

The designer should be aware that a specimen taken in the plane of rolling, and in the direction of the fibers of an aluminum plate, shows as expected 20 per cent elongation. However, this ductility will be reduced to 8 per cent when the specimen is taken in a plane perpendicular to the rolling direction and at an angle of 90 degrees to the plane of rolling.

Finally, while the metallurgical history of a casting is short and well known, the similar history of a wrought part is long and unknown in most cases. Foundrymen, in their sales efforts, should take notice of the following comment made by G. Sachs:

> "The actual properties of a metal depend considerably upon its method of processing or its previous history. For a wrought material, this previous history is not readily defined, as it usually consists of a number of hot working, cold working and annealing operations, each of which can be varied in several respects. The effects of many of these factors are not well understood. Changes in the processing conditions, therefore, frequently result in a product that appears distinctly different from that obtained before the changes were made."

Strength

Since the discovery of ductile iron, foundrymen have enjoyed an enviable position in the structural component field. Never before has their position been so strong, because no cast ferrous material could hardly compete from a combined strength and cost standpoint with carbon steel fabricated shapes. It was not a difficult task for the promoters of weldments or forgings to prove the structural inadequacies of one material or the cost of the other.

The various examples presented later point out the possibilities and achievements of ductile iron castings in applications where strength is the paramount design requirement.

The forging industry has been justly concerned with the ductile iron casting potentialities. In an address presented at a meeting of The Drop Forging Association in 1957, Harry W. McQuaid said the following:

> "What has kept the steel forging so far ahead of the steel or iron casting in the eye of the machine

designer is its great ability to permit a high degree of deformation without fracture. As long as this condition existed, the threat of the casting to the forging was not especially strong. During the past ten years, there has been introduced into the picture a new type of iron casting known as "nodular" or "ductile iron'" which shows definitely improvement in physical properties over the ordinary cast iron part. To the drop forger, this might mean an an important invasion of his field and a possible loss of important tonnage to the foundry."

This potential loss of tonnage also applies to weldments. However, the author would like to sound a word of caution at this point. In their anxiety to compete with weldments from a strength and structural standpoint, foundrymen should not forget that the welding industry has done a commendable job in the field of applied strength of materials. It suffices to look at the voluminous amount of research performed, and literature published by this industry, in an attempt to clarify some particular structural problems faced by the designers. Whether it is the establishment of design criterions for welded connections or the study of a composite beam under various loadings, this continuous concern to provide tools for the designers in the field of experimental stress analysis in structures sometimes not too closely related to welding has paid off handsomely by the gain of markets and the stature of the industry.

Proposed Studies

Because ductile iron is a true structural metal, similar programs should be carried out by the foundries interested in furthering its use. Frequently used cast shapes should be systematically studied to arrive at optimum designs, for the minimum weight and lowest final cost. Although some foundries have undertaken such programs of experimental stress analysis on their own to help their customers reach more satisfactory designs, this practice is not yet generalized. To be of value, such results should be available to all designers and structural engineers and not to a few.

Consequently, it is the author's opinion that these studies should be carried out on an industry-wide scale. The tools are brittle varnishes, photo-elastic coatings, fringe pattern analysis, magnetic particles for qualitative analysis; photo-elastic measurements, strain gages, x-ray analysis, etc., for quantitative analysis. The results would be invaluable to the machine designer.

It is felt that this would do much to show the superiority of ductile iron castings where there is no joint to limit the overall strength. A welded structure is no better than its joints. Besides the residual stresses, and the somehow unpredictable distribution of loading stresses, a welded joint depends greatly upon a human factor. Such discontinuities as sharp corners, notches, weld beads, hard spots, slag inclusions and porosity, which cause obstructions to the flow of stress, are common sources of failure in weldments subjected to repetitive loadings. These points should be a source of concern for the designer contemplating a welded design.

A properly designed and properly cast ductile iron casting eliminates these dangers. Foundrymen are aware of this, but the designer should be continuously kept informed as well as unequivocally convinced.

Production

Ten years of production experience have proved that ductile iron can be used for long or short production runs for parts that shall be machined or not.

Even for short runs it appears that the cost of pattern investment has been overemphasized to such an extent as to detract the production engineers from even thinking in terms of castings. Actually, experience indicates that the patterns, when made of the proper material, selected to last for a known quantity of castings, do not affect the casting unit cost to the extent of being out of proportion with weldments.

The various steps and operations required to complete a weldment gas cutting, positioning, welder or automatic welding units, roll bending, press forming, stress relieving and material handling between each operation have to be accounted for in the final cost analysis of a welded component. They certainly add up to an impressive list, particularly when long production runs are contemplated.

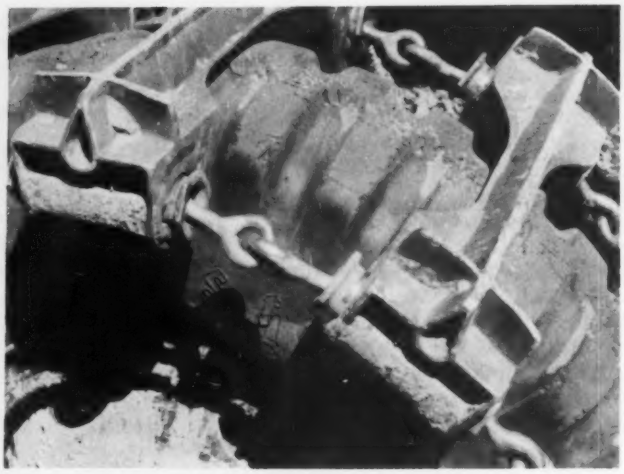
Weldments do not lend themselves too well to machining operations, while ductile iron castings can show savings over other materials. The machining difficulties encountered in welded assemblies are too well known to be developed in detail here. Mention should only be made that the weldment residual stresses cause distortions of the members. The removal of some surface metal will cause the redistribution of these induced stresses. Consequently, the part will go out of shape after machining, sometimes making it impossible to obtain the desired match or alignment.

From a production standpoint, it is evident that the cost of a forging die is not economically justified unless the total quantity of parts numbers high in the hundreds. For instance, a large mobile equipment manufacturer has set up for the engineering department the following rule—all parts which are expected to be run yearly in quantity less than 800 shall be castings. Above 800, the costs between a casting and a forging should be examined.

Cost Reduction

Helping foundrymen are the newer molding methods that were mentioned previously. Combined with ductile iron, they permit foundrymen to produce components of high dimensional integrity. By combining the reduction in excess metal to excellent machinability, ductile iron castings enable the producer to achieve certain cost reductions. The author's company knows of an automotive concern that saved 30 per cent of its original cost in switching its production of forged steel gears to shell molded ductile iron castings (grade 120-90-02). The test bars taken from castings purposely broken showed a complete consistency in mechanical properties. The lowest tensile strength registered was 127,000 psi.

The cost reduction obtained in the production of automobile crankshafts by some manufacturers here and abroad has been achieved with ductile iron



Figs. 1 and 2 (left to right) — Installation of single track shoe wrapped around tandem rear wheels for conversion of truck into half-track vehicle, used for bad weather conditions. Right view shows closeup of installation.

castings. To date, some 20,000,000 crankshafts have been made successfully. Yet all the possible combinations of design ideas and production methods toward lowest finished cost have not been exhausted.

An example is a 50 lb finished weight ductile iron V-8 engine crankshaft. A substantial weight reduction could be accomplished by using a hollow design such as the one made by suppliers for a German car. The geometry of this casting, obtained through precise founding techniques, would be close to the finished dimensions. A subsequent short cycled drop forging or hot coining would further bring the casting down to within a few thousanths of an inch of the final shape. Grinding of the bearing surfaces would complete the part.

This suggested procedure, bold in its approach, is aimed at a vital component of an automobile engine. If iron castings are to hold out against the white metals in the automotive and other fields, it will be through the continuous use of imagination to obtain the maximum performance from the metal properties.

Hot working a ductile iron casting is not a new idea. Harry W. McQuaid proposed it to the Drop Forgers, in an address previously mentioned in this paper, as follows:

> "I would like to submit for your careful consideration in the forging field, the possibility of using cast ductile iron blanks which need the very minimum of hot working to convert them into real forgings. These forgings would be, if properly cooled, of excellent machinability and physically satisfactory . . . (ductile iron) conversion from a cast to a forged product is not difficult to visualize and with enough incentive from the large consumer of forgings and castings, this conversion will follow without fail."

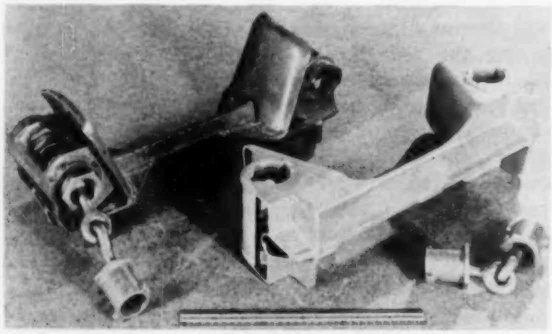


Fig. 3 — Single track shoes shown installed in Figs. 1 and 2.

From an industrial engineering point of view, it is also interesting to compare the energy required to finish a part by forging to that required to make a casting. Jean Fauquemberque, in *Fonderie,* Oct., 1958, reports a figure of 0.7 kwh/lb for electrically melted castings against between 1.4 to 1.7 kwh/lb for a forging. It is worth while to mention this comparative cost aspect as it might be of some interest when contemplating the installation of facilities to produce large quantities of parts.

CASE HISTORIES

Case 1 — Single Track Shoe

This part is a patented design. The track shoe is an element of a strand of track, wrapped around the tandem rear wheels of a truck to convert it into a half-tracked vehicle (Figs. 1 and 2). The shoes (Fig. 3, right) are joined together by dumbbells (Fig. 4) which engage in a two position as-cast bayonet-type socket. Approximately 45 shoe elements are required for a standard vehicle.

Fig. 4 — Shoes (Figs. 1, 2 and 3) are joined together by dumbbells which engage in a two position as-cast bayonet-type socket.

The part was previously made by welding two ductile iron castings to two mild and medium carbon steel components, stress relieved, hard-face welded on the bottom beam and flame hardened on cam surfaces. Because of the severe service requirements, the complete part was converted to a ductile iron casting with a subsequent improvement in physical properties, a weight saving of 15 per cent and a total cost reduction of 45.5 per cent.

The bushings are shell molded, and thus require a minimum of finishing to clean the spherical seat. This is accomplished by one man at the rate of 40 castings per hr. The castings are supplied in a normalized condition, while the ramps where the bushings engage, are flame hardened. A detailed comparison between the two types of fabrication is as follows:

	Weight and Cost	
	Weldment (Fig. 3, left)	Casting (Fig. 3, right, Fig. 5)
Weight, lb.	20	17
Cost of raw material	4.56	4.85
Fabrication labor & overhead	9.18	0
Assembly, painting & bundling	0.75	0.75
Heat Treatment: stress relieving, oil quench & draw	2.00	3.40
Total cost	16.49	9.00

The added advantages found with the castings are:

1) By the decrease in the number of operations, the parts can be produced quicker as castings than as weldments.
2) No fabrication set-up equipment is required with casting.
3) The casting offers much more flexibility to the choice of possible heat treatments, as opposed to the cumbersome steps which had to be used to reach the required properties in the past – normalizing, oil quenching and drawing, flame hardening, hard face welding.
4) The reduction in weight obtained in the redesign is of prime importance to the military users as track has to be carried on the vehicle at the expense of payload.

The life of the casting over the weldment has been found to be at least 45 per cent longer through the endurance tests on the Canadian Army proving grounds in Ottawa.

This part is an example of how the properties of ductile iron can be combined with advanced molding techniques to succeed in a cost reduction coupled with better overall performance.

The quality of castings already produced and on order justify the statement made previously that castings lend themselves perfectly to long production runs with consistent properties.

Case 2 — Parts for a Portable Drill and Pump Unit

This complete unit (Fig. 6) is manufactured by a geophysical research company. It was developed for use in inaccessible locations found in the jungles or mountainous regions of South America. Weight and reliability are the paramount design requirements, since this equipment is transported on the backs of native porters, llamas or by helicopter.

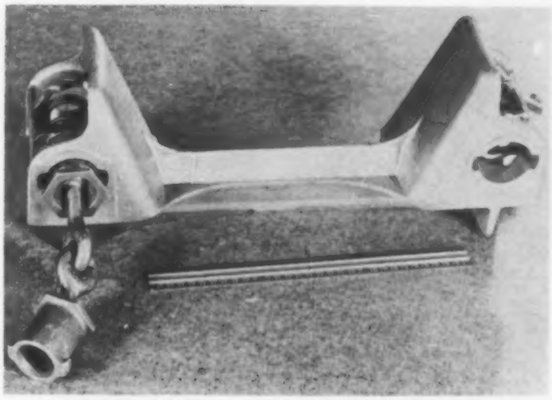


Fig. 5 — Single track shoe casting showing installation of parts in Fig. 4.

The original design was fabricated as a weldment, shown on Fig. 7 (pump section only). A conversion later involved the following parts as shown on Figs. 8 and 9:

1) Pump frame.
2) Cylinder heads (one per unit).
3) Cylinder (one suction and one discharge per unit).
4) Connection rod (two per unit).
5) Drill rotary head casting (Fig. 9).

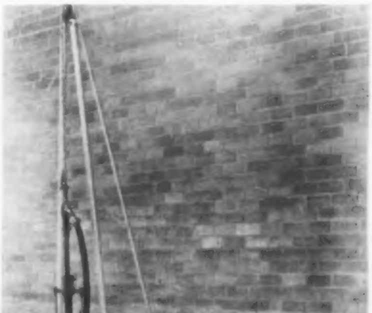
The advantages of this conversion are numerous:

a) Better appearance of parts.
b) Faster production.
c) Pressure tightness and high strength-to-weight ratio.
d) Lower production cost. 30 per cent saved in machining cost, 20 per cent in fabrication cost.
e) Better corrosion resistance, particularly important in tough service conditions.
f) Better wear and erosion resistance.
g) Less vibration.

Case 3 — Dry Manifold for Gas Engine

This part was made by a company for its own use, weight approximately 460 lb. Previously made in low carbon steel weldment, the cost of the completely

Fig. 6 — Portable drill and pump unit, parts of which were made of ductile iron castings (Figs. 8 and 9).



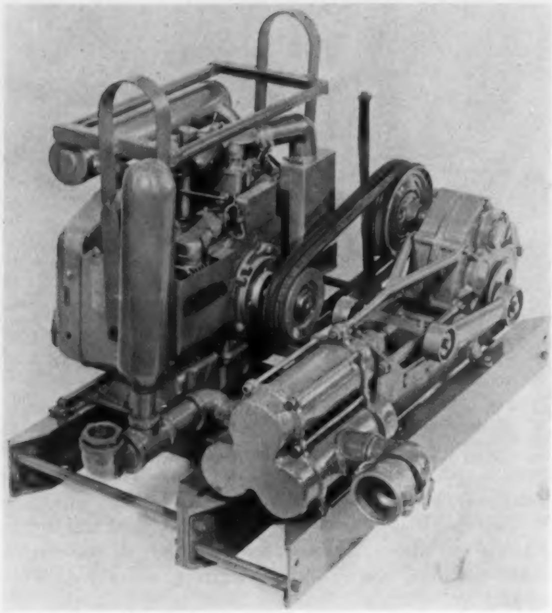


Fig. 7 — Original design of pump and drill unit (Fig. 6) made as a fabricated weldment (pump section only).

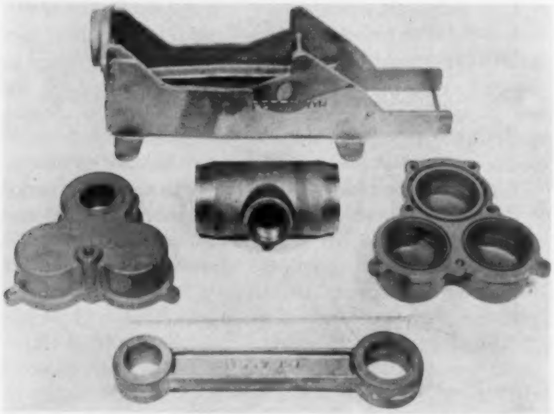


Fig. 8 — Pump frame, cylinder heads, cylinder and connecting rod of unit (Fig. 6) which were converted to ductile iron castings.

Fig. 9 — Drill rotary head casting made of ductile iron for same unit (Fig. 6).

finished part, machined, was \$540.00. When converted to a ductile iron casting (Fig. 10), the finished cost dropped to \$287.00, or a reduction of 47 per cent. Besides this cost reduction, the use of casting permitted a quicker delivery of the part than when made by welding.

Case 4 — 12 in. Diameter Sprocket

This sprocket (Fig. 11) is used on a combine that pulls a rake for harvesting grains. This sprocket is operated at relatively slow speed, from 300 to 400 rpm, and is bolted to a steel plate for support. Made originally from a ½-in. thick plate, the teeth were machined. It was later changed to a grade 80-60-03 ductile iron casting, with teeth accurately cast.

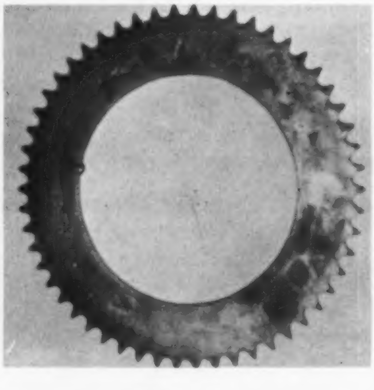
The total cost of an aluminum pattern and follow board amounted to \$90.00. The sprocket cost was \$7.00 when made from steelplate, \$1.91 when cast. The total saving to the customer on approximately 2,000 sprockets produced thus far amounts to \$10,180.00.

Case 5 — Ejection Cam

This cam was originally made from a 2½-in. thick steel plate, finish weight 427 lb. The machining time consisting of milling, drilling and fitting amounted to a total of 34.3 hr. The total cost of the

Fig. 10 — Dry manifold gas engine casting, cost of which was reduced 47 per cent.

Fig. 11 — Diameter sprocket used on a combine that pulls a rake for harvesting grain.



part including material, machining, flame hardened $\frac{1}{16}$-in. deep to 52-58 Rockwell C, was $161.97.

This cam was redesigned as a ductile iron casting (grade 80-60-03), and the weight reduced to 151 lb through judicious use of ribs. The machining time was reduced to 21.3 hr, a time reduction of 38 per cent. The total casting cost, including flame hardening to 52-58 Rockwell C was reduced to $107.05; a saving of 34 per cent. The press operation is reported to be smoother through lowering the cam weight and the better vibration absorbing properties of ductile iron.

Case 6 — Frame for Paper Press

This manufactured frame was originally made with welded steel plates, as shown on Fig. 12. By converting the same to a high strength (100,000 psi ultimate tensile minimum) ductile iron casting, the following was achieved (Fig. 13):

1) Cost saving 25.8 per cent.
2) Ease of machining.
3) Improvement in strength.
4) Better appearance of the finished product.
5) Incorporation in the casting of such auxiliaries as supports, bosses, etc.

Case 7 — Cleat-hopper Track

These cleats are components of a track used to pick up parts in a hopper bin and deliver them to a loading track. Each cleat is approximately 6½-in. long, and was originally made from two pieces (1¾-in. x ½-in. and 1¾-in. x ¼-in. of steel bar stock welded together, the cross-section being an "L" shape. The breakdown of the operations necessary to complete the steel welded design follows:

1) Saw stock to length.
2) Mill ends to 30 degree angle.
3) Mill weld relief for welding to the track.
4) Weld 2 pieces together.
5) Mill three holding welds.
6) Sand blast to remove scale.
7) Heat treat, case harden to 58-60 Rockwell C.
8) Weld to hopper track.

This part was converted to a ductile iron casting (grade 70-50-15) with an as-cast Brinnell of 220. All machining operations were eliminated and the production steps reduced to three:

1) Casting the part.
2) Blast cleaning.
3) Welding to hopper track.

The cost of the weldment was $3.00 per unit against $1.34 for the casting, including pattern cost.

Case 8 — Adjustable Beam Locking Device

This small part is used to hold cross removable beams in special railroad gondola cars to haul steel strip coils. They were originally made by bending three pieces of steel plate, welding them in five separate places and drilling two holes. The weight was 14 lb (Fig. 14).

This part was redesigned and cast in grade 60-45-10 ductile iron. The total weight was reduced to 13 lb (Fig. 15). The castings performed satisfactorily and the cost was reduced from $3.64 as made in the owner's shop, to $3.15 made in another foundry. The schedule of deliveries could be met easily by the foundry in one day, while fabrication of the same quantity of parts required several days.

Fig. 12 — Paper press frame originally made of welded steel plates.

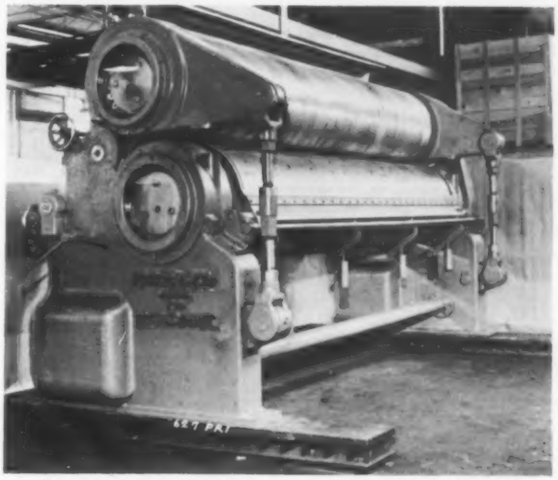


Fig. 13 — Same press frame shown in Fig. 12 made of high strength (100,000 psi UTS) ductile iron.

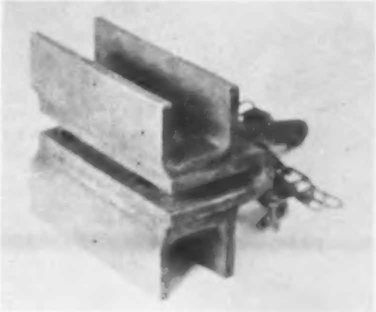


Fig. 14 — Adjustable beam walking device made by bending three pieces of steel plate, welding them in five separate pieces and drilling two holes. Weight, 14 lb.

Fig. 15 — Redesigned part shown in Fig. 14 cast in ductile iron. Weight, 13 lb.

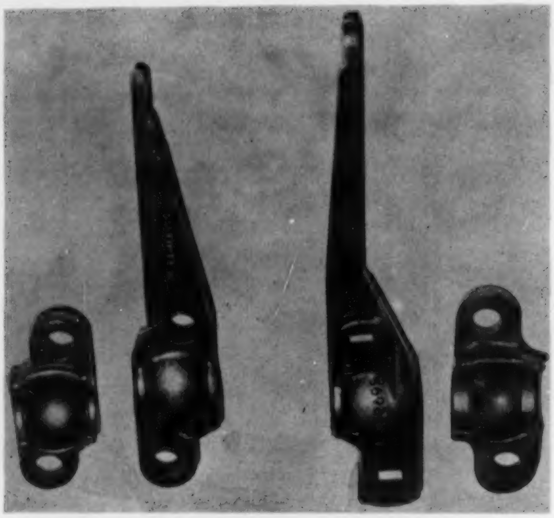


Fig. 16 — Knife heads used on reciprocating cutting mechanisms for grass and grain cutting machines. Left, heat treated forgings. Right, redesigned part made in ductile iron, heat treated for good wear resistance.

Case 9 — Knife Heads

This knife head assembly is used on reciprocating cutting mechanisms for grass and grain cutting machines (Fig. 16). For years these heads were made as forgings and heat treated. They were redesigned to be cast in ductile iron and subsequently heat treated for good wear resistance. The performance of the castings has been excellent, and the cost of the unit made up with castings is less than when made up of forgings.

This case illustrates a condition which is to be currently found. It involves a change in design which justifies the shift from one method of fabrication to another. Once a part is established as a forging, it would hardly be economical to discard the serviceable die equipment.

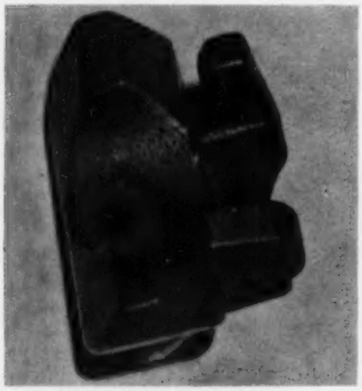


Fig. 17 — Governor weight weighing approximately ½ lb.

Fig. 18 — Gas engine crankshaft made in ductile iron.

Case 10 — Governor Weight

This part (Fig. 17) weighing approximately ½-lb was previously made as a forging of about the same weight. It was found more economical when redesigned to produce it as a ductile iron casting hardened for better wear resistance. The service performance was also found to be superior to the forging.

Case 11 — Gas Engine Crankshaft

This crankshaft (Fig. 18) is incorporated in a completely new 200 hp-475 rpm gas engine. This new engine can utilize the standard power take-off unit or be connected directly to compressors, pumps or other oil field equipment. Because of the performance of ductile iron cast shafts in older engines, and its bearing properties and damping capacity, ductile iron was selected for this new engine. The pattern cost was far less than the cost of dies to forge this shaft from steel, thereby resulting in a considerable cost reduction.

Case 12 — Electric Cable Pipe Roller Supports

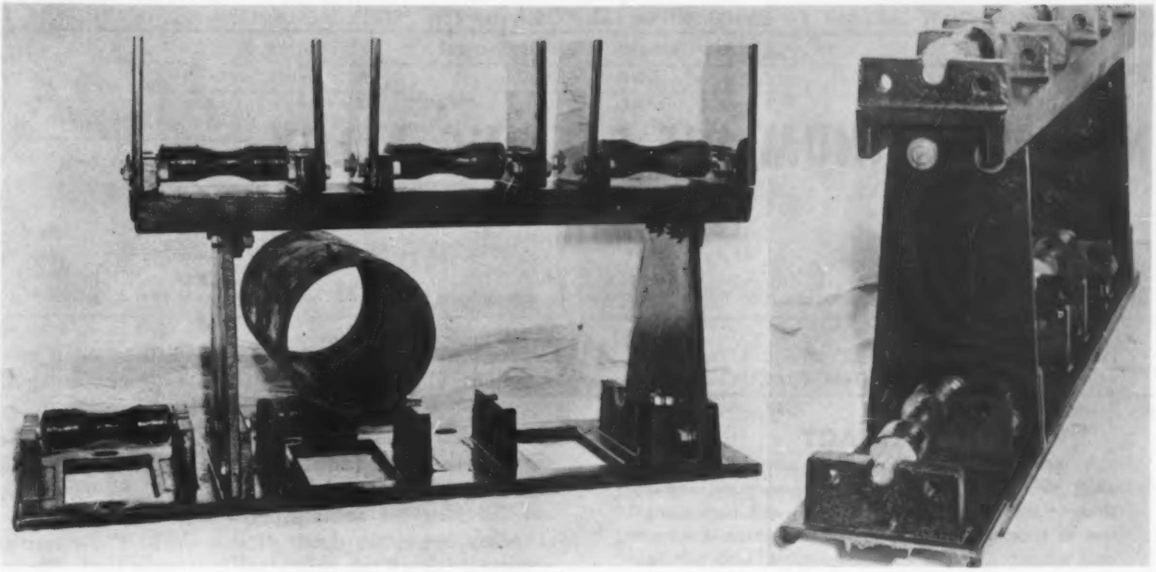
Although this example is not a true conversion, it is felt that it should be included as part of this paper for it is the result of a fabrication method study during the design stage. The company was faced with the problem of installing special new electrical conduits (Figs. 19, 20) in a practically inaccessible location of the Queensboro Bridge. The conduit supports were to possess a good corrosion resistance as well as high strength to resist the various stresses induced by the bridge movements. A cost study indicated that a ductile iron casting was not only more economical than a welded steel assembly, but also answered all the requirements of this installation. The complete casting including rollers were made of grade 60-45-10 ductile iron annealed under an extremely rigid quality control. A preliminary radiographic inspection of the castings was made to determine the gating system which would result in a no-residual stress as-cast condition.

Subsequently, a radiographic inspection was required on at least one casting of each of the first, the middle and the last ladle of the day's melt. Tension tests specimens from 1 in. keel blocks were also taken from the same ladle and heat treated with the castings before being machined and tested.

This case, the author's company believes, is an example showing that a ductile iron casting can be produced in large quantity (close to 1,000 complete supports) with a near-perfect metal structure.

Case 13 — Coupling Bar

This part serves as a connection between the tractor and an implement (Fig. 21). The forging was welded to a support member which is bolted to a tractor. It was redesigned as a ductile iron casting to combine two components into one, thus eliminating one assembly operation and permitting incorporation of cored holes in this new design. This redesign resulted in a lower composite unit cost with equal performance.



Figs. 19 and 20 (left and right) — Two views of ductile iron electric cable pipe roller supports installed on Queensboro bridge.

ACKNOWLEDGMENTS

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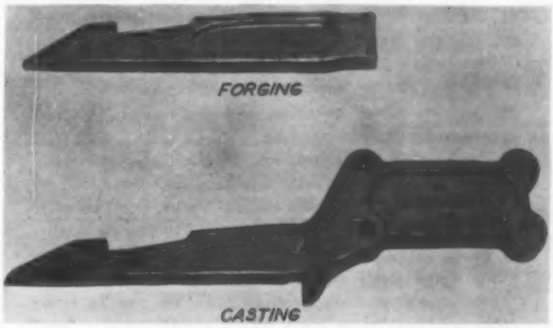


Fig. 21 — Coupling bar used as a connection between the tractor and an implement, redesigned from forging (top) to ductile iron casting (bottom).

NEW ALUMINUM DIE-CASTING ALLOY

By J. H. Moorman and E. V. Blackmun

ABSTRACT

A new aluminum die-casting alloy,* designated alloy 364, has been developed for structural applications which require tensile strength and high elongation or toughness. The nominal composition is 8.5 per cent silicon, 0.30 per cent magnesium, 0.30 per cent chromium and 0.03 per cent beryllium. In the as-cast condition, die castings of alloy 364 provide a combination of tensile properties and elongation comparable to those of alloy 218, and are suitable for structural applications requiring toughness.

The artificially aged (-T5) temper provides good elongation and a high yield strength. Annealed alloy 364 can be joined to other parts by rolling, spinning or riveting without cracking.

The casting characteristics, physical properties, corrosion resistance and machinability of alloy 364 are similar to other Al-Si die-casting alloys, such as alloy SG100B (commercial designation 360). The castability is good, permitting the die casting of thin walled or complicated parts which are difficult to cast in alloy G8A (commercial designation 218). Its use in structural applications or parts which require drastic forming can increase the applications for die castings.

INTRODUCTION

Aluminum die-casting alloys provide various combinations of mechanical or physical properties and castability to fit engineering design, casting requirements and cost. When maximum ductility and strength are required the binary aluminum–8 per cent magnesium alloy G8A (commercial 218) is suitable, except where its relatively poor castability causes poor quality castings, casting problems and higher costs. In spite of its superior properties, machinability and corrosion resistance, the use of alloy G8A die castings is limited to simple shapes.

The new die-casting alloy 364 is the result of investigations to develop an alloy which has the excellent mechanical properties of alloy G8A and better castability. Another objective is to provide an alloy which will undergo an increase in tensile properties and retain good elongation when subjected to a low temperature thermal aging treatment. In view of the known, desirable properties and castability of aluminum-silicon alloys, these alloys were used as a base in searching for an improved alloy.

Alloy 364 is the result of this work. The nominal composition of the new alloy is 8.5 per cent silicon, 0.30 per cent magnesium, 0.30 per cent chromium and 0.03 per cent beryllium. The common impurities, copper, iron, manganese, zinc, nickel and tin are controlled at the normal levels used in commercial die-casting alloys.

PROCEDURE FOR CASTING AND TESTING

In preparing melts or heats, alloying and melting practices are similar to those employed with alloy SG100B (commercial 360). The chromium and beryllium contents require slightly higher melting and holding temperatures, to obtain rapid melting and to prevent precipitation of the highest melting point compounds in the alloy. Metal holding and casting temperatures are 1200 to 1225 F. Frequent stirring will prevent precipitation at local cold spots in the furnaces.

Standard A.S.T.M. die-cast specimens were used to determine mechanical and physical properties. Properties of die castings from production dies were measured with static breakdown, impact and bending tests.

An artificial aging treatment consisting of 10 hr at 340 F is used to produce the high yield strength 364-T5 temper. Annealing for 2 hr at 650 F produces

TABLE 1 — TYPICAL MECHANICAL PROPERTIES[1] OF DIE-CASTING ALLOYS

Commercial Alloy and Temper	A.S.T.M. Designation	Tensile Str., ksi	Yield Str. (offset –0.2% ksi	Elong., % in 2 in.	Endurance Limit,[2] ksi	Shear Str., ksi
364-F	–	43	23	7.5	18	26
364-T5[3]	–	46	33	4.0	—	—
364 annealed[4]	–	27	13	11.0	—	—
218-F	G8A	45	27	8.0	20	29
360-F	SG100B	47	25	3.0	19	30
380-F	SC84B	48	24	3.0	21	31

1. Tensile properties are average values obtained with A.S.T.M. standard 1/4-in. diameter round specimens produced on a cold chamber machine.
2. R. R. Moore type specimen, 500,000,000 cycles.
3. Artificially aged 10 hr at 340 F.
4. Annealed 2 hr at 650 F.

*Covered by U.S. Patent 2,823,995 issued to Aluminum Co. of America.

J. H. MOORMAN is Asst. Chief, Chicago Section, Alcoa Rsch. Labs., Aluminum Co. of America, Chicago, and E. V. BLACKMUN is Asst. Chief Met., Fabricating Div., Aluminum Co. of America, Pittsburgh.

TABLE 2 — MECHANICAL PROPERTIES OF ALLOY 364 AFTER AGING AT VARIOUS TEMPERATURES

Aging Time, Hr	Room Temperature Properties[1] After Aging at: 150 F			250 F			300 F		
	Tensile Str., ksi	Yield Str., ksi	Elong., % in 2 in.	Tensile Str., ksi	Yield Str., ksi	Elong., % in 2 in.	Tensile Str., ksi	Yield Str., ksi	Elong., % in 2 in.
½	40.5	21.6	5.4	41.7	22.9	6.0	39.7	23.1	5.1
3	39.7	22.2	4.5	41.7	23.0	6.8	41.9	26.7	4.8
24	41.5	23.2	5.8	42.4	25.3	5.0	49.5	36.0	4.6
72	41.9	22.8	7.0	44.2	29.5	4.1	48.1	35.7	3.4
360	43.0	23.4	7.3	49.3	35.6	4.6	44.9	30.5	4.8
2400	45.4	26.9	7.9	46.9	34.3	4.5	42.7	28.2	5.6
10,000	46.0	27.7	6.0	45.4	28.8	6.5	41.7	26.1	5.6

1. Averages of four tests on standard A.S.T.M. ¼-in. diameter cold chamber die-cast test bars.

the high ductility required for joining the die castings to other parts by rolling, riveting or spinning.

MECHANICAL AND PHYSICAL PROPERTIES

The mechanical properties of alloy 364 are of particular interest when the yield strength and elongation are compared to alloys G8A, SG100B and SC84B. A comparison of typical mechanical properties is shown in Table 1. Alloy 364-F die castings provide high tensile properties and the excellent toughness or ductility, shown by a typical elongation of 7.5 per cent. Artificial aging to the -T5 temper increases yield strength 10 ksi while retaining a desirable degree of toughness at 4.0 per cent elongation. In the annealed condition alloy 364 can be joined to other parts by rolling, spinning or riveting operations without cracking the die castings.

In view of the use of aluminum alloy die castings under conditions of intermittent or continuous exposure to moderately elevated temperatures, the effect of aging up to 10,000 hr at 150, 250 and 300 F was determined with standard A.S.T.M. test bars. The room temperature mechanical properties are shown in Table 2 after aging for the various periods of time.

The physical properties and other characteristics of alloy 364 are listed in Table 3.

CASTING CHARACTERISTICS AND HEAT TREATMENT

Die castings of alloy 364 are made commercially using production dies and machines. Castability is rated as good, being comparable to that of alloy SG100B and superior to alloy G8A. Alloy 364 die castings are used in the as-cast (-F), artificially aged (-T5) and annealed tempers. As shown in Tables 1 and 2, various combinations of mechanical properties can be obtained with these tempers.

APPLICATIONS

Alloy 364-F is particularly suitable for die-cast parts which require high tensile strength and ductility or impact resistance. The static load and impact test results in Table 4 show the excellent strength and ductility of 364-F alloy die castings. In one series of tests, a lever arm part was tested to failure in static load and impact testing machines. The static test setup is shown in Fig. 1. This part is subject to high bending and impact loads in service. The test results and service of this part show the superior ductility of alloy 364.

The second series of tests in Table 4 compare

TABLE 3 — PHYSICAL PROPERTIES AND CHARACTERISTICS OF ALLOY 364

Specific gravity	2.63
Weight/cu in.	0.095
Electrical conductivity, per cent I.A.C.S., -F Temper	30
Thermal conductivity at 25 C, C.G.S. units, -F Temper	0.29
Average coefficient of thermal expansion/deg. Fahr.	
Range -58 to 68 F	10.8
Range 68 to 212 F	11.6
Range 68 to 392 F	12.2
Range 68 to 572 F	12.7
Approximate melting range	1035-1115 F
Resistance to hot cracking	Excellent
Pressure tightness	Good
Die filling capacity	Excellent
Resistance to corrosion	Good
Machinability	Good

TABLE 4 — STATIC LOAD AND IMPACT PROPERTIES OF ALLOY 364 DIE CASTINGS

Part	Alloy Designation: Commercial	A.S.T.M.	Static Breakdown Test: Load at Failure —lb	Deflection at Failure —in.	Impact Test: No. of Blows to Failure
Lever Arm	364-F	—	317	1.02	18
	218-F	G8A	308	1.03	10
I-Beam Bracket	364-F	—	3600	0.217	18
	364-T5	—	4250	0.081	10
	218-F	G8A	4150	0.219	15
	360-F	SG100B	3580	—	6
	380-F	SC84B	3610	—	5

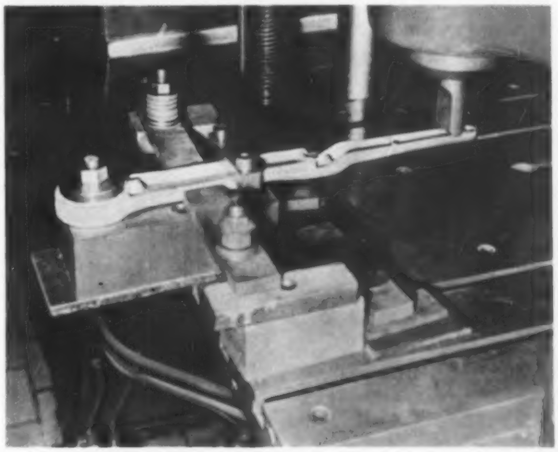


Fig. 1 — Breakdown testing of lever arm part made of alloy 364.

Fig. 2 — Bending deformation of alloy 364 showing extent to which the aluminum alloy can be deformed.

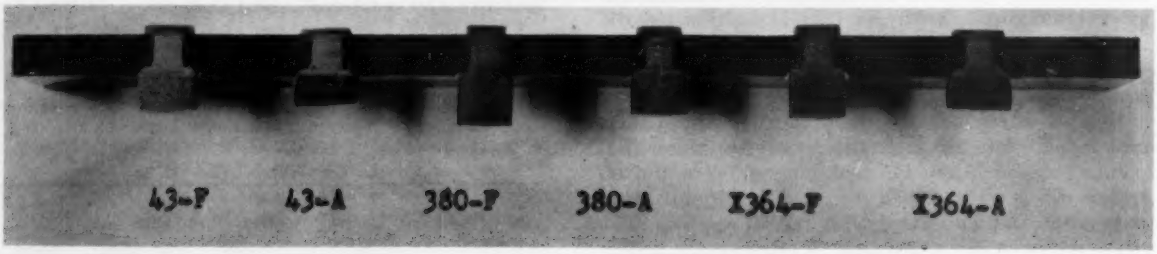
static breakdown and impact test results on the I-beam section of a structural bracket, illustrating the excellent properties of alloy 364. In both cases, the parts are produced in alloy 364. Although alloy G8A die castings show similar test results, high production scrap resulted from shrink cracks and poor castability.

For applications which require assembly of die castings by rolling, spinning or riveting, annealed alloy 364 is of considerable interest. Tensile properties in Table 1 and bent test bar in Fig. 2 show the extent to which alloy 364 annealed 2 hr at 650 F can be deformed. A standard test bar has been bent approximately 360 degrees around a radius equal to two times the diameter. Similar bends have been made over a radius of 1½ diameters. Another forming application of alloy 364 is illustrated by Fig. 3.

All of the rivets shown were machined from die-cast tensile test bars and cold headed between flat steel dies with a force of 4500 lb/rivet. Although the three alloys formed satisfactorily in the test, forming alloy SC84B caused cracks to develop in production castings, and poor castability limits alloy S5C to simple parts. Alloy 364 die castings are rolled, spun or riveted with satisfactory production results.

Alloy 364-F is recommended for die castings requiring high strength and ductility of impact resistance. In the -T5 aged temper, the alloy provides high tensile strength, good elongation and high yield strength.

Fig. 3 — Rivets formed from grip ends of aluminum alloy die casting test bars. All rivets were machined from die-cast test bars and cold headed between flat steel dies with a force of 4500 lb/rivet.



SOME PRINCIPLES FOR PRODUCING SOUND Al-7Mg ALLOY CASTINGS

By W. H. Johnson and J. G. Kura

ABSTRACT

Principles were developed for the production of sound horizontal castings of the Al-7Mg alloy. They were developed from a study of the relationship that exists between the thermal gradients at the center line of the casting and various conditions such as the size of the casting as well as the location of gates, risers and chills. Numerous embedded thermocouples established the thermal history during solidification of the castings. The experimental work was performed on elementary shapes — plates and bars.

It was found that the feeding range of a side riser decreased as the section thickness increased. Unsoundness occurred when the thermal gradients fell below 5 F per in. The feeding range of an end riser was increased by 50 per cent or more by using wedge-shaped chills on the drag surface of the casting. Chills placed at the end of the casting opposite the riser did not increase the feeding range of the riser. Marked improvement in tensile properties were obtained on plates that were cast with wedge-shaped chills, as compared with similar unchilled plates that were also sound.

Adverse temperature gradients were created by a top riser on horizontal plate castings which were 2 in. thick. As a result, shrinkage occurred in the vicinity of the riser. An insulating sleeve on a top riser increased the degree of soundness somewhat, but did not increase the feeding range of the riser. A marked improvement in soundness was obtained, however, when multiple gates were used with a top riser.

INTRODUCTION

The solidification of castings has been studied by numerous investigators.[1-7] Much has been learned concerning the solidification characteristics of both ferrous and nonferrous alloys.[1] The maximum distance that risers will feed the solidification shrinkage in ferrous castings has been determined and, as a result, formulas for the correct dimensioning of risers to be used on certain ferrous castings[2,3] have been evolved. However, complete determination of feeding ranges in nonferrous casting alloys has not been made. At best, the size of nonferrous risers can only be approximated from the charts and formulas available for certain ferrous alloys.

Therefore, it was considered desirable to develop principles governing the location of gates, risers and chills on nonferrous castings. Such information should result in improved casting soundness.

In the past, procedures were worked out empirically when castings of a new design were first produced. In recent years, however, practical methods have been evolved for estimating in advance the correct dimensions of risers to feed many types of castings of low-carbon grades of steel,[2,3] ductile iron[4] and some grades of stainless and heat-resistant steels.[5] Similar research on the risering of nonferrous alloys and ferrous alloys, other than those that were mentioned, has been quite limited to date.

To determine the principles of thermal dynamics that produce sound nonferrous castings for armor, research was sponsored at Battelle Memorial Institute by the Ordnance Tank Automotive Command, Detroit Arsenal, Center Line, Mich., under Contract No. DA-33-ORD-2434, and was guided by the Research Committee of the Light Metals Div., American Foundrymen's Society.* The Al-7Mg alloy was selected as representative of a typical light nonferrous alloy for armor purposes. It was well suited to the investigation because it is known to produce gross shrinkage when inadequately fed. In addition, the alloy has good welding characteristics which would make it desirable for final adoption by the Ordnance Corps as nonferrous armor plate.

Thermal Dynamics Investigation

Essentially, complex castings are combinations of plate and bar shapes of different sizes. Therefore, one series of experiments was designed to investigate the thermal dynamics of plate castings; the other series covered bar castings. The term "thermal dynamics" as used here refers to the study of how thermal gradients in a casting originate, progress and are affected and controlled by changes in the location of the gates, risers, and chills.

The effects of the following variables on the thermal gradients within these castings during solidification were investigated:

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*The Research Committee of the Light Metals Div., AFS, consisted of the following members: W. E. Sicha, *Chairman;* W. Bonsack, D. J. Henry, W. J. Klayer, J. G. Mezoff, C. E. Nelson, T. D. Stay, and R. F. Thomson. G. P. Messenger, who represented Detroit Arsenal, S. Lipson, who represented Frankford Arsenal, and R. W. Zillman and C. B. Jenni, all served as ex officio members of the committee.

1) Riser position.
   a) Side riser.
   b) Top riser.
2) Single and multiple gates.
3) Chill location.
4) Gate location.

The experiments were designed to study the effect that only one riser has on the soundness of the casting. In commercial foundry practice, multiple risers would be used on castings larger than the ones that were studied. Where the large commercial casting can be broken down to multiple units of the experimental castings, it becomes apparent that combining multiples of the simple castings would constitute the commercial casting. Thus, the principles of thermal dynamics of casting the simple unit shapes could be applied intelligently to a large complex shape.

The present investigation is restricted to a study of individual horizontal plates and bars. For a precise application of principles of thermal dynamics to complex shapes, it is necessary to have knowledge of the interaction that exists during solidification between different section thicknesses. Knowledge of the effect of different orientations of adjoining sections on the thermal dynamics is also needed. These are areas for future investigation.

The thermocouple technique[1] was chosen as the most suitable for studying the thermal dynamics of casting. Briefly, the technique consists of obtaining cooling curves from thermocouples placed at strategic locations in a solidifying casting, and establishing the complete history of movement of the freezing front. A strip-chart temperature recorder was used which is capable of recording temperature readings from 16 thermocouples within 30 sec.

GENERAL CONSIDERATIONS

In the past, the gating and risering procedure to produce sound castings of a new design was developed by trial and error. Later cumbersome mathematical methods, based on empirical relationships were employed for ferrous castings. As a result of recent investigations,[3] however, these methods[6,7] are no longer necessary. Now the proper riser dimension is readily obtained through the use of a simple shape factor. This shape factor is

$$\frac{L + W}{T},$$

where

L = length of casting, in.
W = width of casting, in.
T = thickness of casting, in.

The original data obtained by Bishop, et al.,[3] in establishing the empirical relationship between the shape factor and the ratio of riser volume to casting volume for low-carbon steel are shown by the dotted area in Fig. 1. Trend lines for various ductile irons,[4] and for some highly alloyed steels,[5] are also shown in Fig. 1. The straight-line relationships between the shape factor and the R_v/C_v ratio for these ferrous alloys establish the boundaries between sound and

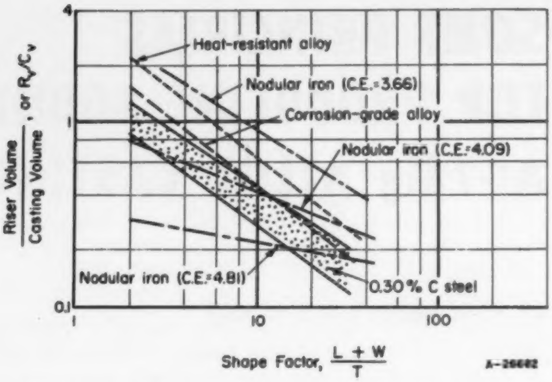

Fig. 1 — Relationship between known shape factors and R_v/C_v ratios.

unsound castings. Castings with shape factors and R_v/C_v ratios above the trend lines would be sound. For example, to make a sound casting from ductile iron with a carbon equivalent of 3.66, the minimum R_v/C_v ratio would be 1 for a shape factor of 8.

To date, the correct dimensions of risers that will feed a casting adequately have been established for ferrous alloys only. Of particular interest is the fact that a straight-line relationship exists between the shape factor and the R_v/C_v ratio for each alloy studied.

Ferrous Alloy Castings

The data contained in Fig. 1 are based upon the fact that the feeding range of risers used with ferrous alloys has been found to be 4½T for plates, and $6\sqrt{T}$ for bars, where T is the thickness in in. This means that when making ferrous alloy castings of simple design the feeding distance increases as the section thickness increases. However, research on the risering and feeding ranges of nonferrous alloys has been quite limited. Therefore, when this research was started, it was not known whether this relationship applied to nonferrous alloys.

The straight-line relationship between the shape factor and the R_v/C_v ratio could be assumed to be acceptable if the feeding range of the Al-7Mg alloy were to increase as the section thickness increased. Since no data were available to specify the size of riser that is required to feed the Al-7Mg alloy, the volume of the risers used in this investigation was determined from the data in Fig. 1 for the 0.30 per cent carbon steel. The size of the riser was selected as if it were intended to feed steel plates ½, 1 or 2 in. thick having a length and width of 5T. In the course of the investigations, the length of the Al-7Mg alloy plates was varied to determine the actual feeding range of the riser.

In previous research,[8,9] improved horizontal gating systems were developed that would deliver clean metal to the mold cavity with a minimum amount of turbulence. The gating system used in the present research was a simplified version of the ideal system. The simplified version was used because 1) it was easily constructed, and 2) the objective of the investigation was to study the principles affecting soundness rather than cleanliness.

TABLE 1 — PLATE, CUBE, BAR AND RISER DIMENSIONS FOR Al-7Mg ALLOY CASTINGS

Plate Dimensions, in.					Riser Dimensions, in.	
Thickness, T	Width, 5T	Length 3T	Length 5T	Length 8T	Diameter 2½T	Height Above Plate, H
½	2½	1½	2½	4	1¼	5
1	5	3	5	8	2½	5
2	10	6	10	16	5	5

Cube and Bar Dimensions, in.				Riser Dimensions, in.	
Thickness, T	Width, T	Length T	Length 4T	Diameter 1½T	Height Above Bar, H
2	2	2	8	3	5
3	3	3	12	4½	5
5	5	5	—	7½	5

EXPERIMENTAL PROCEDURE

The dimension of the plates, cubes, bars and risers that were used in the experiments are shown in Table 1. Three thicknesses of plates and cubes were used. For each thickness of plate, three different lengths were studied. Two thicknesses of bars were used with a length of 4T. The diameter of the riser used with the plates was 2½T. For the cubes and bars, the diameter of the riser was 1½T. The height of the riser when placed on the top of the casting was 5 in. When used as a side riser, the riser height was equal to the thickness of the casting plus 5 in. All of the plates, cubes and bars were cast horizontally. Additional information concerning the location of the gates, risers and chills is presented in later portions of the paper devoted to the analysis of the thermal history of the castings.

Heats of Al-7Mg alloy were prepared in a clay-graphite crucible in a high-frequency induction furnace. The melts were heated to 1400 F and degassed with chlorine so that the shrinkage voids in the cast plates would not be influenced by variable gas content in the melts. About ¼-lb of chlorine was bubbled through the 50-lb melts in the 5 min degassing period. Immediately following the degassing operation, a sample was dipped out of the furnace and allowed to solidify under a vacuum at a pressure of about 75 mm.

If no evolution of gas occurred during its solidification, 0.005 per cent beryllium was added to the melt as a 2.5 per cent beryllium-aluminum master alloy to protect the melt against oxidation during pouring. Grain refining elements were intentionally not added to the melt. The melt was then transferred to a preheated ladle and poured at 1350 F. Commercial grade aluminum (99.85 per cent purity) and magnesium (99.8 per cent purity) were used to prepare the melts. The average iron and silicon content of the melts was 0.07 and 0.06 per cent, respectively.

The molds were made by the cold-setting binder process. The sand mix used was as follows:

Silica sand, AFS fineness no. 65 — 100 lb.
Cold-set binder — 3 lb (2 per cent).
Cold-set activator — 0.3 lb (0.2 per cent).

The sand and binder were mulled together for 6 min. After the activator had been added, the mix was mulled for an additional 2 min. The permeability of the sand after mulling was between 52 and 56. After baking for 1 hr at 400 F, the molds had a hardness between 85 and 90.

Thermocouple and Radiographic Techniques

The thermocouple technique was chosen as the most suitable for studying the thermal dynamics of casting. To obtain the thermal history during solidification of the castings, thermocouples were embedded midway between the top and bottom faces of the plates and bars. As many as 16 thermocouples were placed at selected locations in a single casting.

Thermal studies, although informative, are quite time consuming to conduct. Some experiments, therefore, were conducted in which no thermal data were obtained during the solidification of the castings. The effect of changes in the location and dimension of the chills, risers and gates on soundness was then determined radiographically.

Radiographs were made of the whole casting to determine the presence of shrinkage voids and their location. Vertical sections were removed that extended from immediately in front of the riser to the end of the plate or bar. In addition, sections were made at other locations in the castings in which the presence of shrinkage voids was suspected, but not clearly indicated by radiographs of the whole casting. These sections, in turn, were radiographed so that the cross-section of the plate or bar could be examined more accurately for shrinkage voids.

Thermocouple Data

From the data obtained from the embedded thermocouples, curves were constructed of temperature versus distance from the riser at specific time periods after the castings were poured. The drawings in the middle horizontal row in Fig. 2 illustrate the type of plot. Similar plots were also made of the temperature distribution across the middle of the castings. From these graphs, the longitudinal and lateral thermal gradients were determined for the castings at their center line.

A thermal gradient is the difference in temperature that exists between two points divided by the distance between them. In this investigation, it is the difference in temperature between two points 1 in. apart at the moment that solidification starts at the point farther from the riser. Examples of plots of thermal gradients are shown in the upper horizontal row of Fig. 2. The thermal gradients were determined at the solidus temperature.

RISER POSITION EFFECT

Plates With Side Riser

A considerable amount of information can be obtained from the end-of-freeze waves on the effects that changes in the location of riser, chills and gates have on the solidification of castings. End-of-freeze isotherms were drawn at specific time intervals after pouring was completed. Positions of the end-of-freeze isotherms for the 1-in. thick plates of Al-7Mg are illustrated by the sketches in the bottom row in Fig. 2.

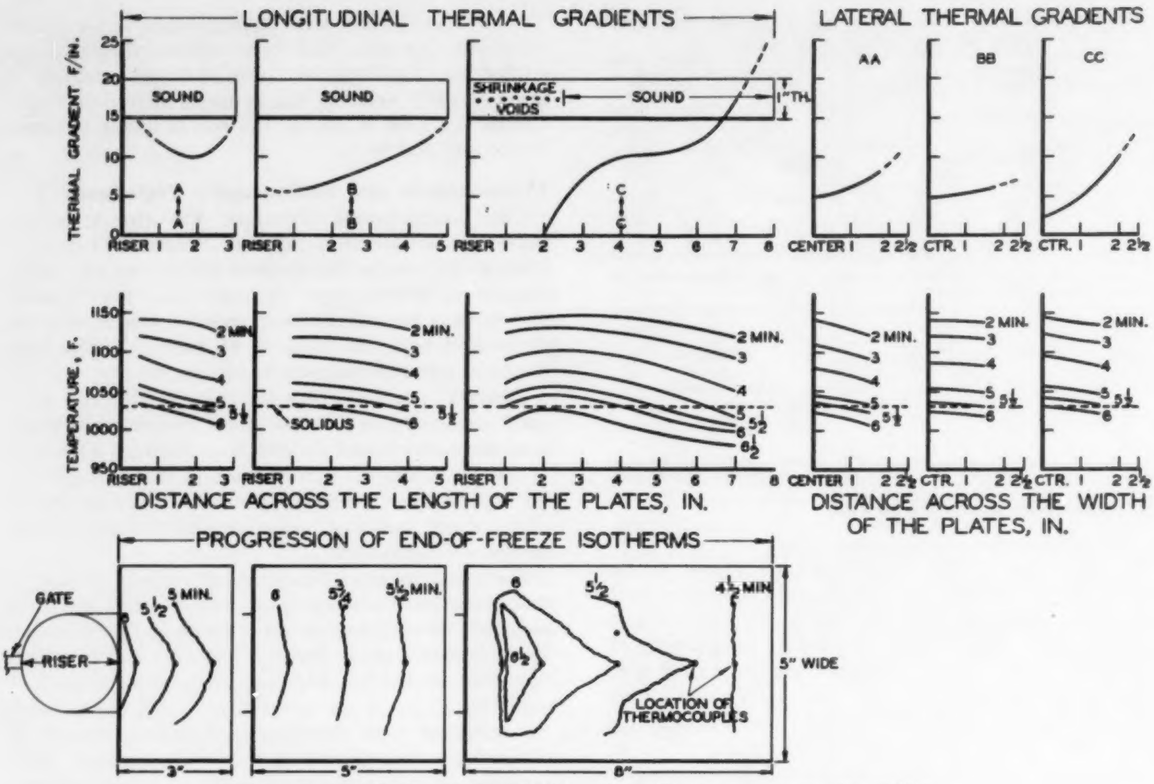

Fig. 2 — Longitudinal and lateral thermal gradients present at the solidus temperature (1030 F) during solidification of 1 in. thick Al-7Mg alloy plates.

The first group of experiments consisted of making the nine plate castings listed in Table 1. The data obtained from these nine plates were intended to establish the minimum thermal gradient required to produce castings free from shrinkage voids. The plates were made with a side riser and cast horizontally, as illustrated in Fig. 3.

The graphs in Fig. 2 illustrate the type of thermal history that was obtained. In this instance, the data are for plates 1 in. thick, 5 in. wide, and 3, 5 or 8 in. long, with a 6-in. riser that is 2½-in. in diameter.

The curves, in the upper horizontal row of Fig. 2, show that both the longitudinal and lateral thermal gradients decrease near the riser as the length of the plate increases. Shrinkage voids were not detected in the two shortest plates (3 and 5 in.). The lowest thermal gradients in these two plates were 5 F per in. Shrinkage voids were present in the longest plate (8 in.) in the region in which the analysis of the thermal history of the plate disclosed that no thermal gradient existed.

End-of-Freeze Isotherms

A study of the end-of-freeze isotherms reveals the movement of the freezing front. Solidification in the shortest plate was highly progressive toward the riser, and became less so as the length of the plate increased. In the longest plate, directional solidification stopped about 6 min after the casting was poured. By this time, solidification started to develop near the riser while liquid metal still existed at a point further distant from the riser. Consequently, when the trapped molten metal solidified within this portion of the plate, shrinkage voids developed. These data show that the limit of the feeding range of the riser for a 1-in. thick plate is about 5 in., or 5T.

The longitudinal and lateral thermal gradients for the ½- and 2-in. thick plates, as well as two special 1-in. thick plates, are shown in Fig. 4. No shrinkage voids occurred in the ½-in. thick plates because the thermal gradients were quite large. The longitudinal thermal gradients in the longest plate (4 in.) approached the minimum of 5 F/in. required for complete soundness, and established 4 in. (8T) as the limit of the feeding range of the riser for this thickness of plate.

Controlled directional solidification was not achieved in the two longest 2-in. thick plates (10 and 16 in.), and shrinkage voids were present through-

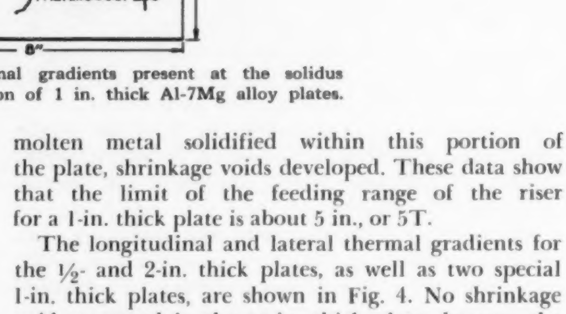

Fig. 3 — Location of gate and side riser for cast plates.

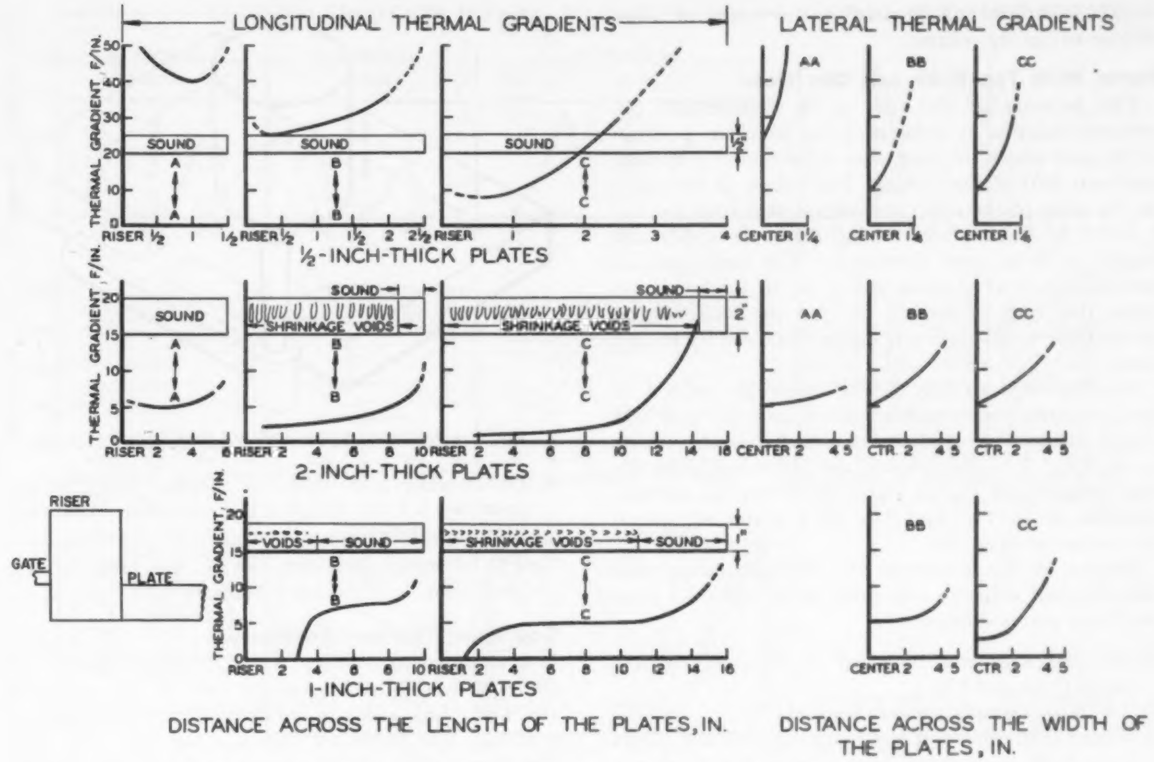

Fig. 4 — Longitudinal and lateral thermal gradients present at the solidus temperature (1030 F) during solidification of ½- and 2-in. thick Al-7Mg alloy plates.

out most of these two castings. Large thermal gradients existed near the farthest edge of the two plates because of the chill effect that the mold always creates on the edge of a casting. Farther from the edge of the plate, heat was lost uniformly, and low thermal gradients occurred across most of the plate. Therefore, directional solidification was not achieved, and shrinkage occurred.

Controlled directional solidification was barely sufficient to achieve soundness in the shortest plate (6 in.). These data establish that the limit of the feeding range of the riser for a 2-in. thick plate is 6 in., or 3T.

Thermal Gradients Effect

The correlation of the normal gradients at the center line with the presence of shrinkage in the nine plates shows that shrinkage voids will be present in plates of Al-7Mg when the thermal gradients fall below 5 to 8 F/in. In addition, it was concluded that the feeding range of a riser decreases as the section thickness of a plate increases. It is apparent that feeding of the aluminum-alloy plate castings as a function of thickness does not follow the general rule for steel castings of the same shape and having the same design of gates and risers.

The thermal gradients in the 2-in. thick plates were small. Furthermore, it was shown that the feeding range of a riser, in terms of *T*, was greater in thinner plates. Therefore, experiments were conducted to determine whether directional solidification could be increased in plates of the same dimensions as the two longer 2-in. thick plates, but with a reduction in thickness to 1 in. This change in thickness doubled the ratio of riser volume to casting volume.

Thermal Gradients vs. Shrinkage

The relationship between the thermal gradients and the presence of shrinkage in these particular 1-in. thick plates is shown in the lower row of Fig. 4. Although the thermal gradients in the center of these 1-in. plates were larger than in the companion 2-in. plates, the thermal gradients fell to zero in front of the riser, which was the portion of the plate that solidified last. A region in which no thermal gradients exist extended over a relatively small area in the center of the 10-in. long plate, and extended for a considerably greater distance in the 16-in. long plate. Radiographs revealed that shrinkage voids were present along the center line of both 1-in. plates. However, only a small amount of shrinkage was present in the 1-in. plate that was 10 in. long.

The presence of shrinkage at the center line shows the importance of the magnitude as well as the direction of the thermal gradients during solidification. When the thermal gradients are large, the beginning and end-of-freeze waves are close together, interdendritic channels are short and open and the flow of feed metal can take place without difficulty. When the thermal gradients are nonexistent or small, as in the 2-in. thick plates, the interdendritic channels may extend the length and width of the plate. Feeding under these conditions is difficult. Furthermore, the data show that controlled directional solidification cannot be achieved in the Al-7Mg alloy by the

simple expedient of increasing the ratio of riser volume to casting volume.

Plates With Top Riser and One Gate

The location of the riser is of considerable importance because it influences the ultimate position of the gate which, in turn, also influences the thermal gradients within the casting. The effect of changing the location of the riser was investigated only for the 1- and 2-in. thick plates having the same width and length as those used previously. The investigations were confined to plates 1 and 2 in. in thickness, because the work described in the previous section showed the ½-in. plate was sound when fed by an end riser.

As illustrated in Fig. 5, the riser was located at the geometric center of the plates, and the gate was placed at the edge of the plate which was the closest to the riser. The locations of the risers and gates are also indicated in Figs. 6 and 7, in which the thermal histories of the 1-in. and 2-in. thick plates are shown in a series of diagrams.

Graphs in Fig. 6 present the thermal history that was obtained with the 1-in. thick plate. The data from the three plates showed:

1) No shrinkage was observed in the two shortest plates (3 in. and 5 in.).
2) The 8-in. long plate was not sound.
3) Thermal gradients at the extremities of the plates were high because of edge effects, but decreased beneath the riser.

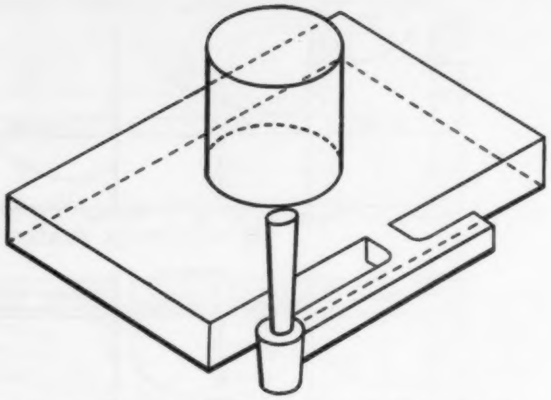

Fig. 5 — Location of gate and top riser for cast plates.

4) In the plate 5 in. long, the thermal gradients approached 5 F/in., which is the minimum value that would result in a sound casting.
5) The thermal gradients under the riser of the plate 8 in. long dropped below 5 F/in.

Top Riser Thermal Gradients

A comparison of Figs. 2 and 6 shows that, when the riser was moved from the end to the center of the 1-in. thick plate, a different pattern of thermal gradients was produced. When a top riser was used, the last portion of the plate to solidify was directly beneath the riser. The thermal gradients in this region

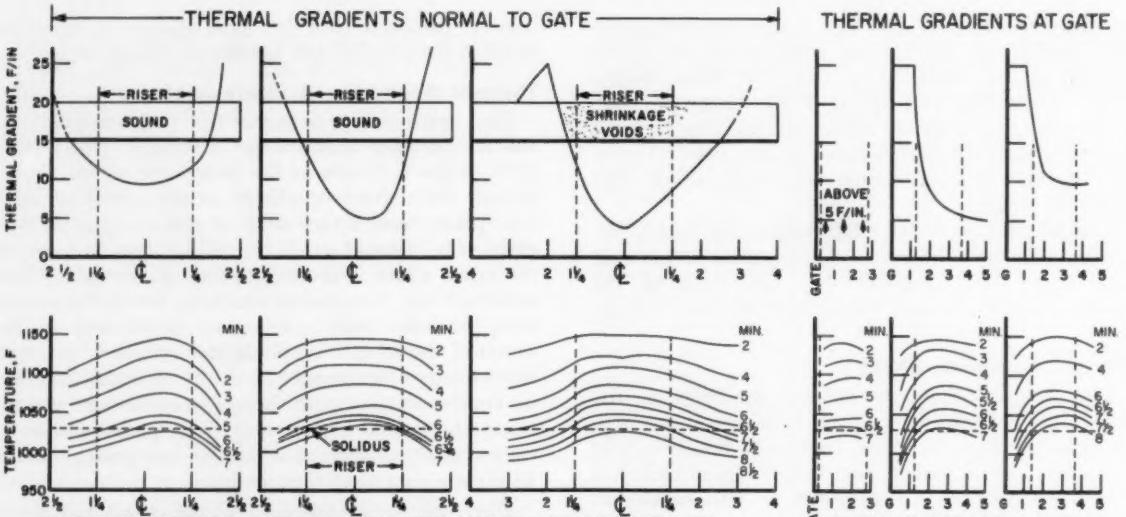

Fig. 6 — Longitudinal and lateral thermal gradients present at solidus temperature (1030 F) during solidification of 1 in. thick Al-7Mg plates fed by a center riser.

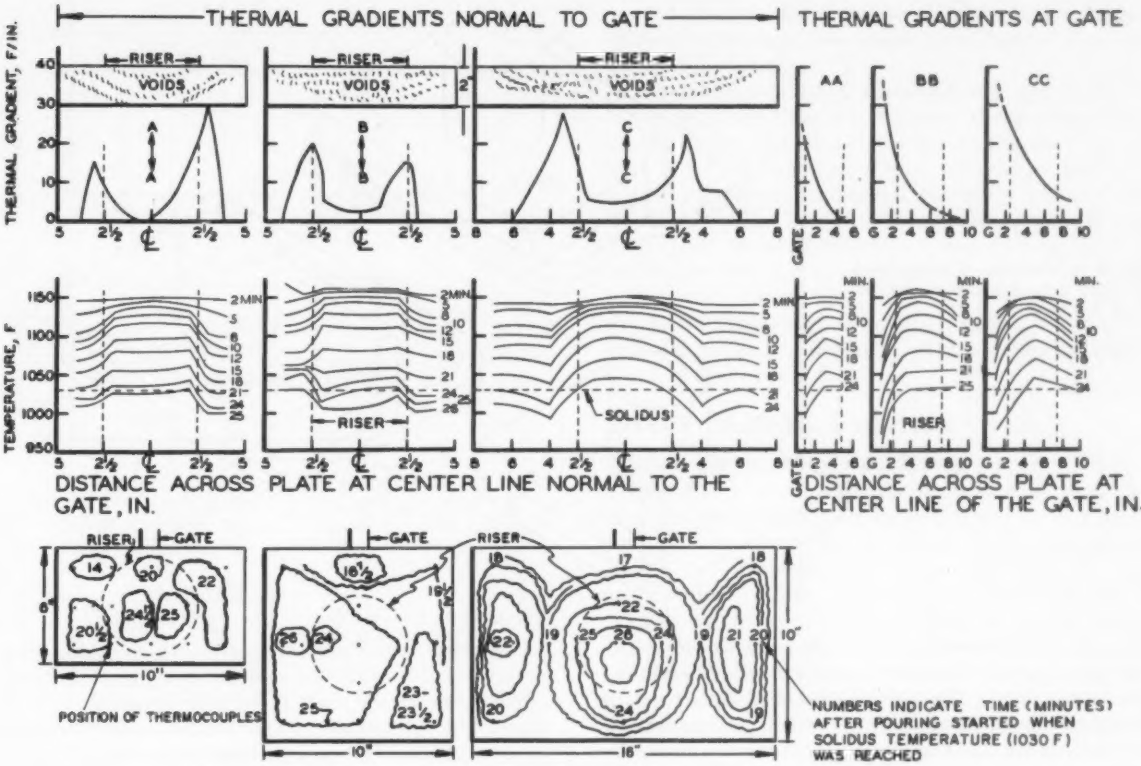

Fig. 7 — Longitudinal and lateral thermal gradients present at solidus temperature (1030 F) during solidification of 2 in. thick Al-7Mg plates fed by a center riser.

were at a minimum. Large thermal gradients, however, existed at the edges of the plate.

In the plate gated and fed at one edge, the thermal gradients were high at the edge opposite the riser, but were at a minimum immediately in front of the riser. With either the side riser or the center riser, the 3-in. long and 5-in. long plates were radiographically sound, and the 8-in. plates were not sound. Regardless of riser position, the thermal gradients in the 8-in. plates fell below the 5 F/in. required for soundness.

The thermal history of the 2-in. thick plates is given in Fig. 7. The date obtained from the three plates show the following:

1) Small thermal gradients exist in the center line of the plates directly beneath the riser and at the extremities at either side of the gate.
2) The largest thermal gradients occur in the region immediately adjacent to the riser.
3) Shrinkage voids are present throughout the plate, but are particularly severe under the riser.

In the absence of both large thermal gradients and controlled directional solidification, shrinkage voids developed throughout the plates. Thermal gradients were not so large during the late stages of solidification as during the earlier stages. If castings are to be sound, molten metal must be supplied by the riser to feed the solidification shrinkage of the last as well as the first portion to solidify. The end-of-freeze isotherms in Fig. 7 show that this was not attained with the 2-in. plates. In the longest 2-in. thick plate (16 in.), for example, the region immediately adjacent to the riser solidified before solidification was completed in all regions farther from the riser.

A comparison of Figs. 4 and 7 shows that, for the 2-in. thick plates, more favorable gradients were obtained with an end riser than with a center riser. The shortest 2-in. thick plate (6 in.) cast with a center riser was not sound. The same plate cast with an end riser, however, was sound. It is apparent that unless large thermal gradients can be produced and extended toward the riser, the riser actually may make the feeding of solidification shrinkage more difficult.

Jackson[10] found in a leaded gun-metal block casting that, as the top riser was increased from a size too small to yield directional solidification to a size larger than necessary for this purpose, porosity first decreased to a minimum and then increased. This increase in porosity with the larger top riser was attributed to thermal gradients that were reduced to values below those required to obtain maximum soundness.

The experiments with the 1- and 2-in. thick plates show that the effectiveness of a top riser decreases as the section thickness increases. Also, in 2-in. thick plates, a top riser has a shorter feeding range than a side riser.

Plates With a Top Riser and Multiple Gates

A single gate attached to the edge of a plate having a top riser creates a localized hot spot by prolonged heating of the sand in the immediate vicinity of the gate. Directional solidification is decreased and shrink-

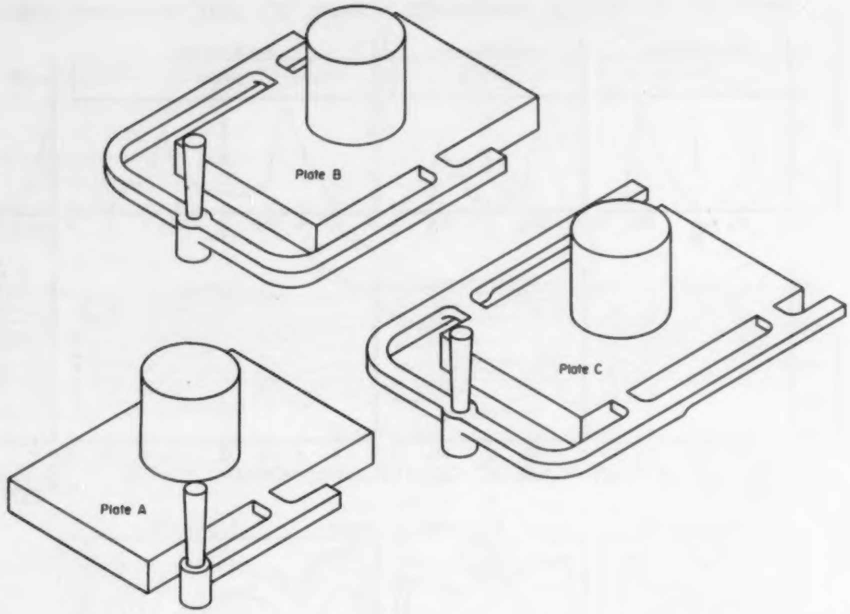

Fig. 8 — Location of single and multiple gates for cast plates fed by a top riser.

age occurs in the casting. Multiple gates would be expected to produce a more uniform distribution of the metal within the mold cavity and thus help to bring about uniform feeding.[1] Such gating systems are directly opposed to those employed to obtain directional solidification. However, if the foundryman must use a top riser and must avoid severe shrinkage voids, multiple gating may achieve this objective provided a certain amount of microporosity can be tolerated.

The effect of increasing the number of gates to 2 or 4 per plate was investigated for plates measuring 1 x 5 x 8 in. and 2 x 6 x 10 in. These sizes were chosen because with a top riser they were not radiographically sound when a single gate was attached to one edge. The multigating systems are illustrated in Fig. 8.

No thermal history of the plates was obtained, but the soundness of the plates as revealed by radiographs is depicted in Fig. 9. For comparison, the data for similar plates fed by a top riser and a single gate are included in the figure.

The soundness of the 1-in. thick plates was improved markedly by using either 2 or 4 gates per plate. Only fine microporosity could be detected directly beneath the riser. Soundness in the 2-in. thick plates was also improved, but coarse microporosity occurred beneath the riser. In both the 1- and 2-in. thick plates, the microporosity was less noticeable when 4 gates were used. It was concluded that multiple gates increase the soundness because the metal is distributed more uniformly throughout the mold cavity and localized hot spots are avoided. As a result, microporosity is more uniformly dispersed throughout the casting.

Two-In. Thick Plate With an Insulated Top Riser

The earlier experiments with single-gated, 2-in. thick plates showed that the shortest plate, which measured 6 in. long by 10 in. wide, was free of shrinkage when it was cast with a side riser, but shrinkage voids were present throughout the plate when a top riser was used. A similar plate was cast to determine whether an insulated top riser would develop sufficiently high thermal gradients in its immediate vicinity to overcome the high thermal gradient that exists in the vicinity of the gate. In the experiment, the riser insulation consisted of a thoroughly dried dental plaster cylinder that was 5 in. high, 5 in. inside diameter, with a 1-in. thick wall.

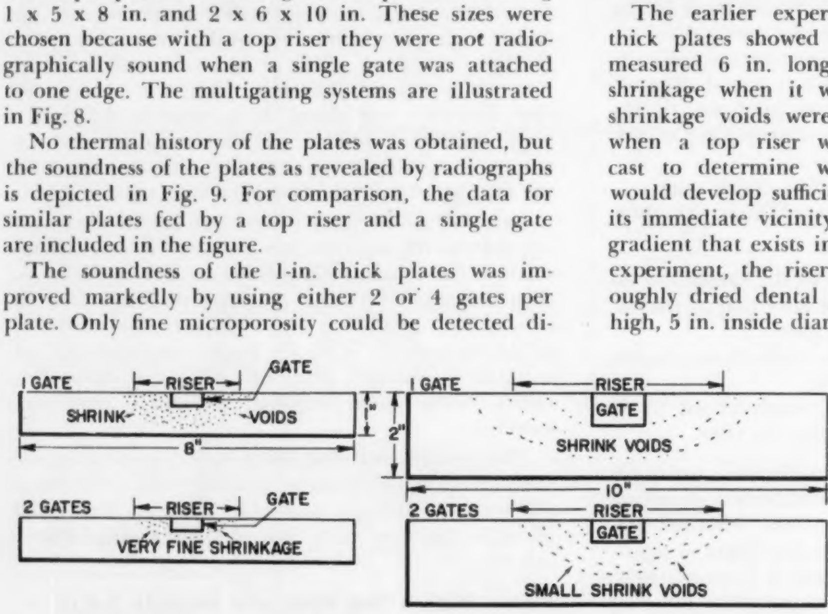

Fig. 9 — Distribution of shrinkage voids in 1- and 2 in. thick plates when gated with single or multiple gates and fed by a top riser.

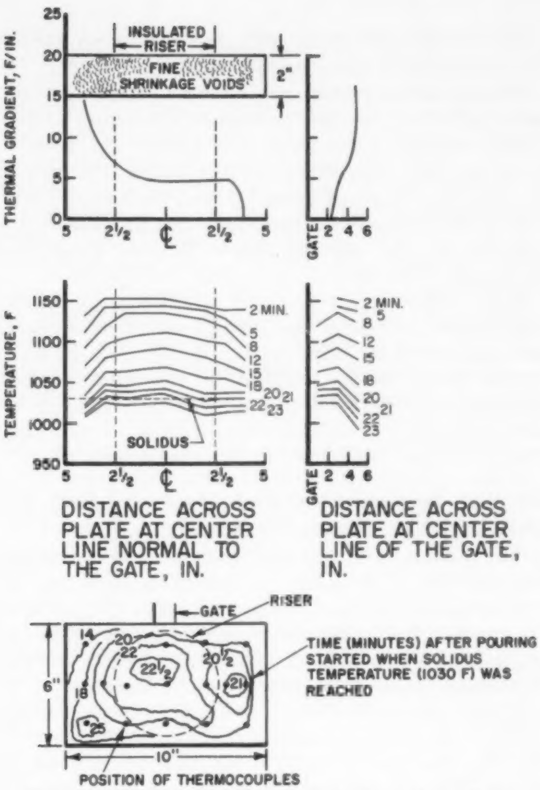

Fig. 10 — Longitudinal and lateral thermal gradients present at solidus temperature (1030 F) during solidification of a 2-in. thick plate measuring 6 x 10 in. fed by an insulated center riser.

Figure 10 shows that, on the average, larger thermal gradients were present in the center line of the plate cast with the insulated riser than with an uninsulated riser (Fig. 7). However, most of the thermal gradients were less than 5 F/in. As a result, small shrinkage voids were again present throughout the plate. No increase in feeding range was detected.

The feeding range of the riser could be increased only if the temperature of the metal in the riser could be raised appreciably to increase the thermal gradients between the riser and the plate. However, the insulating sleeve merely increased the time of solidification of the metal in the riser. As a result, the thermal gradients in the vicinity of the riser remained below the minimum required to obtain maximum soundness.

Riser Diameter Reduction

Decreasing the diameter of the insulated riser will reduce the time for solidification of the metal in the riser but, because of the short feeding range in the 2-in. thick plates, shrinkage will still occur under the riser. To demonstrate this in principle, the insulated 5-in. diameter riser 5 in. high was replaced by an insulated 2½-in. diameter riser also 5 in. high. Soundness was improved near the extremities of the plate, but shrinkage voids were again present directly beneath the riser. The smaller insulated riser was beneficial because more of the cope surface of the plate was chilled by the mold wall. Consequently, the high thermal gradients at the edge of the plate were extended toward the top riser. However, the thermal gradients beneath the riser were below those required for soundness.

It must be concluded, therefore, that the insulating sleeve by itself does not increase the feeding range of the riser. The feeding range of the riser can be said to be increased only when shrinkage under the riser is completely eliminated. When the plate is within the feeding range of the riser, an insulating sleeve can be used to increase the casting yield by decreasing the size of riser that is needed. It should be kept in mind that insulating sleeves must be dry at the time that the mold is poured. If the sleeve contains moisture, this will result in somewhat earlier freezing of the riser.

EFFECT OF CHILL LOCATION

Chilled Plates With Side Risers

The effect of chills on the soundness of steel castings has been studied to a great extent.[11-13] The investigations showed that a chill of T thickness placed at the end of a steel plate or bar opposite the riser, increases the feeding range by 2 in. for plates and by T in. for bars.[11] Tapered chills made gun-metal castings pressure tight even when the melt from which the castings were produced had a high gas content.[12] Information on the effect of conventional chills on the thermal gradients in nonferrous castings is, however, scarce. Such data are necessary if improved techniques for production of sound, light metal castings are to be established.

The effect of steel chills placed along the edge of the Al-7Mg alloy plate opposite the riser was selected for the initial investigations. Chills in this location could be used advantageously in commercial foundries to produce sound castings. The investigations were confined to plates 1 and 2 in. in thickness because the work described in an earlier section of this paper showed the ½-in. thick plate was sound without chills. The dimensions of the chills were as follows:

	Plate Dimensions, in.		
Chill Dimension, in.	Thickness	Width	Length
1 x 1 x 5	1	5	3, 5, 8
2 x 2 x 10	2	10	6, 10, 16

The thermal gradients established in the plate by using end chills are shown in the two upper rows in Fig. 11. The minimum longitudinal thermal gradient in the two shortest 1-in. thick plates (3 and 5 in.) and in the shortest 2-in. thick plate (6 in.) was about 15 F/in. No shrinkage voids were detected in the radiographs of these plates even though the lateral thermal gradient in the center of the 2-in. thick plate was down to about 5 F/in.

Shrinkage voids were still present in the 1-in. thick plate 8 in. in length, and in the two 2-in. thick plates 10 in. and 16 in. in length. Although the thermal gradients near the chilled end of these plates were as large as 100 F/in., the gradients decreased either to less than 5 F/in. or they no longer existed at the location where shrinkage voids developed. Comparison of the unchilled and chilled plates (Figs. 4 and 11, respectively) shows that, in the vicinity of the

chills, higher thermal gradients were present in the 1-in. thick plate than in the 2-in. thick plate.

Nevertheless, the rate of cooling near the riser was similar in both thicknesses of plates. As a result, feeding from the riser in the last stage of solidification was difficult and shrinkage voids developed.

End Chill Influence

These studies show that end chills exert a potent but short-range influence on the rate of solidification. After a solid skin forms next to the chill, heat must be extracted through the solidified metal. Thus, the thermal conductivity of the solidified metal becomes the controlling factor for dissipation of heat into the chill. As a result, the effect of the chill on controlling directional solidification does not extend to a great depth into the casting.

Two additional 2-in. thick plates were cast to determine whether directional solidification of the desired degree could be obtained readily with steel chills in locations other than at the far edge of the plate. Because the shortest 2-in. thick plate (6 in.) was sound radiographically, only the two longest plates (10 and 16 in.) were cast. Two 2x2x10-in. steel chills were used with each plate. One chill was again placed along the edge opposite the riser, and the other chill was in contact with the drag surface across the width of the plate at the center.

The chills were placed at the center because the thermal gradients at this location in the two longest plates with an end chill equaled the minimum thermal gradient (15 F/in.) present in the shortest 2-in. thick plate.

The magnitude of the thermal gradients present in the two plates is shown in the bottom row of Fig. 11. Although thermal gradients increased in the immediate vicinity of the chill located in the center of the plates, sections of the plate at a distance of about *T* from the chill were relatively unaffected. The immediate demand for feed metal by both the end and bottom chills caused gross shrinkage voids to form in the top half of the castings almost directly above the center chill.

The reduction in thermal gradients to values approaching zero near the risers showed that solidification was completed about 2 in. from the riser in both of the plates before sections of the plate farther from the riser were completely solidified. It must be concluded, therefore, that center chills of the type described here are ineffective in promoting soundness.

Air Gap Formation Between Plate and End Chill Effect on Thermal Gradients

The inability of the end chill to maintain a continuous high rate of heat removal has been attributed to the formation of an air gap between it and the casting. To observe the effect that the formation of an air gap may have upon the establishment of the thermal gradients, 2-in. thick plates measuring 6 by 10 in.* were cast with an end chill placed along the 10-in. edge. The opposite edge had a side riser to which the gate was attached. With the first plate, plate *A* of Fig. 12, the chill was used in the conventional

*A plate of this size was radiographically sound when fed by an end riser and not chilled.

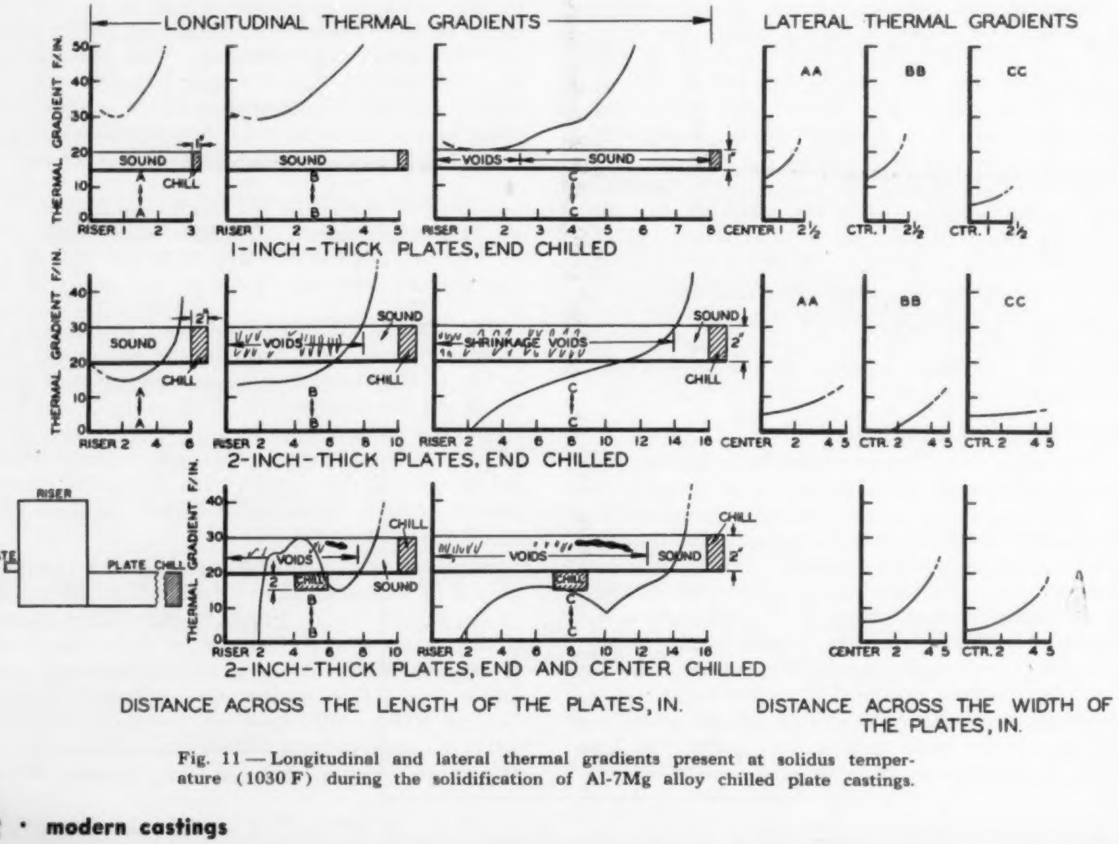

Fig. 11 — Longitudinal and lateral thermal gradients present at solidus temperature (1030 F) during the solidification of Al-7Mg alloy chilled plate castings.

manner and, therefore, the plate was free to contract away from the chill as solidification progressed.

The chill used with the second plate, plate *B*, contained two bolts which projected from the chill face into the mold cavity. Thus, the chill was, in effect, bolted into permanent contact with the cast plate during solidification of the casting.

The thermal history in Fig. 12, obtained from thermocouples embedded in the chill and the casting, showed that an air gap did develop when the chill was not deliberately secured to the casting. The air gap developed approximately 8 min after the pouring of the plate was started. During this period, the thermal gradients present at the solidus temperature in plate *A* were essentially the same as those in plate *B*, which had no gap between the casting and the chill. However, a greater rate of cooling below the solidus temperature was obtained in plate *B* than in plate *A*.

Although the increase in the rate of cooling was attributed to the continued contact between the plate and the chill, the increased rate occurred after solidification was completed. Thus, these experiments demonstrated that more continuous extensive directional solidification cannot be expected from end chills that are made to retain contact with the casting throughout the solidification period of the casting.

The maximum temperature of the chill was higher when a gap was present between the plate and the chill. Its higher maximum temperature was attributed to the fact that the melt for casting plate *A* was about 25 F hotter. The probability also existed that the thermocouple in the chill was located slightly closer toward the casting that had the loose chill than was the case for the casting that had the fixed chill. Under more precise experimental conditions, it is believed that both types of chills would reach essentially the same maximum temperature. In any event, the apparent difference in maximum temperature of the chills had no effect on the extension of directional solidification in the casting.

Wedge-Shaped Chills and Their Effect on the Thermal Gradients and Soundness of 1- and 2-In. Thick Plates

Work by Johnson, et al.,[10] had shown that the proper combination of thermal gradients and directional solidification necessary for soundness can be obtained more readily by using wedge-shaped chills. To demonstrate this, several 1- and 2-in. thick plates were made with wedge-shaped chills.

The 1-in. thick plates were cast with two chills, and the 2-in. thick plates were cast with four chills. Both thicknesses of plate were fed by an end riser to which the gate was attached. The two chills used with the first 1-in. thick plate measuring 5 by 8 in., plate *C* of Fig. 13, were 7½-in. long and 1½-in. thick, and tapered in width from 2½-in. to ⅛-in. These chills were located in the drag and were positioned parallel with each other. Their wide end was set at the edge of the plate opposite the end riser. Thus, the chills extended the length of the plate to within ½-in. of the risered edge.

Radiographs of the plate with tapered chills (plate *C*, Fig. 13) showed that shrinkage was present for a distance of only about 1 in. from the risered edge, as compared with a distance of 2½-in. in either an unchilled plate (plate *A*) or in a plate with an end

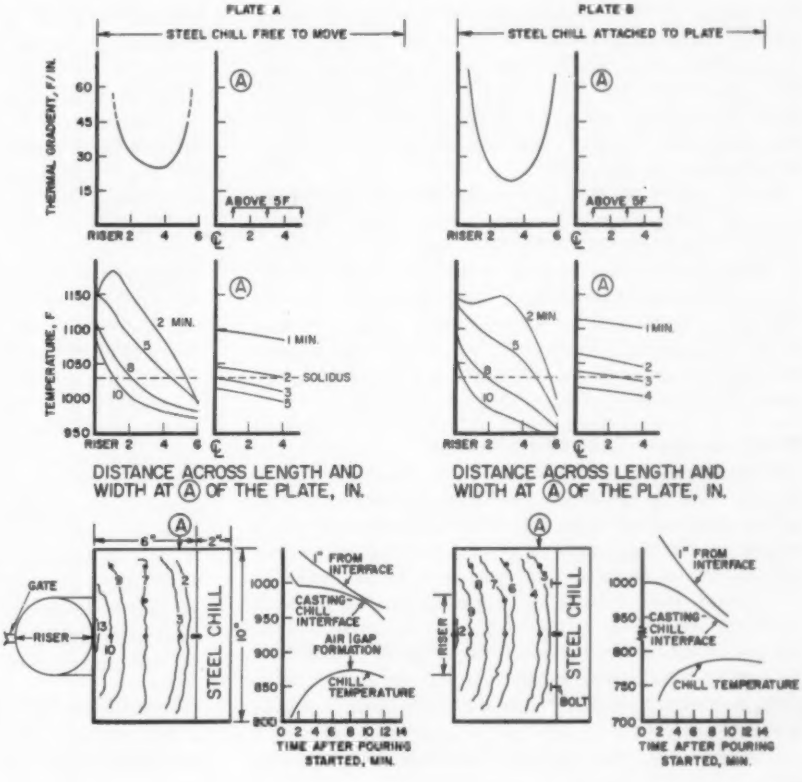

Fig. 12 — Effect on the thermal gradients of the formation of an air gap between the plate and the chill placed at the end opposite the riser of 2-in. thick Al-7Mg plates.

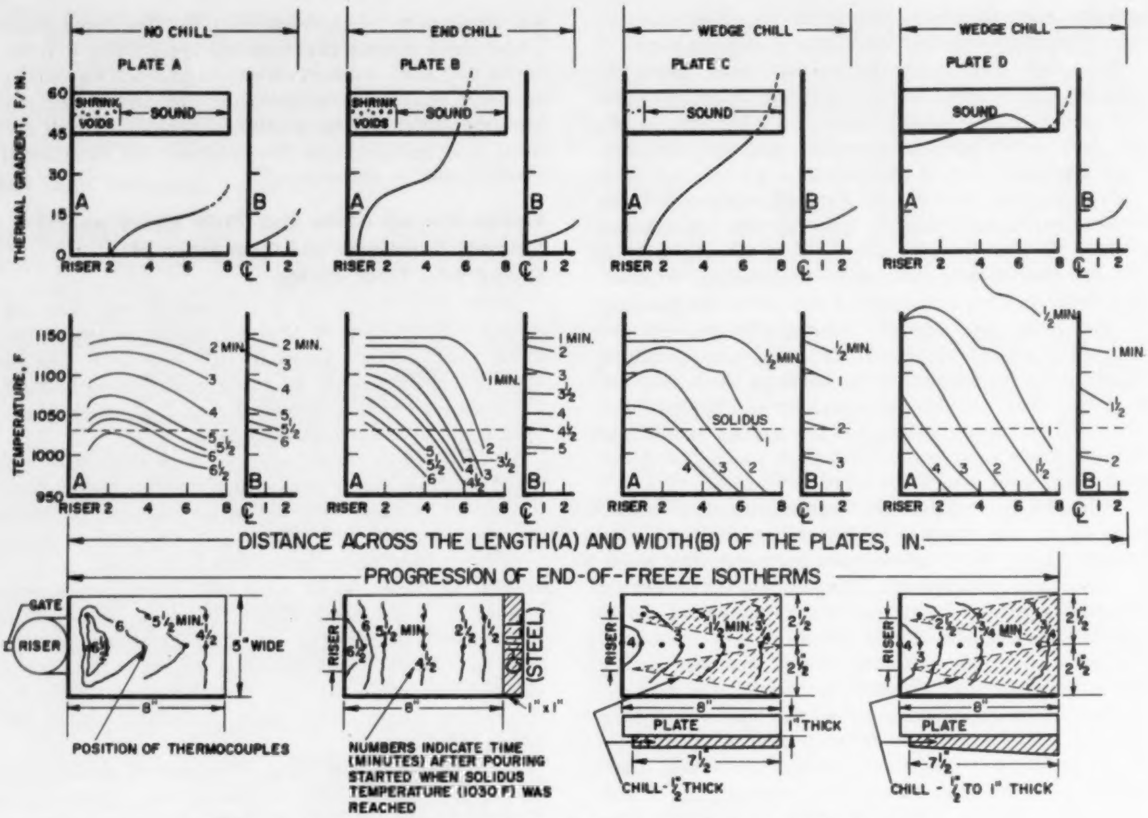

Fig. 13 — Comparison of the thermal gradients and soundness obtained in 1-in. thick plates measuring 5 x 8 in. when chills are plated at the end opposite the riser and when wedge chills are placed along the length of the plate.

chill (plate *B*). The thermal history in Fig. 13 shows that the thermal gradients in all three of the plates dropped to zero at the location where shrinkage voids developed. However, in plate *C* the wedge-shaped chills had produced large thermal gradients which extended close to the riser and markedly extended the soundness in the plate.

The tapered chills used with the second plate, plate *D*, were similar to those used with plate *C*. However, the thickness of the chills tapered from ½-in. at the narrow end to 1 in. at the wide end. Thus, the chills had a taper both in width and in thickness. Radiographs showed that plate *D* was sound. Longitudinal thermal gradients throughout the plate were in excess of 35 F/in. Lateral thermal gradients were large enough to assure soundness.

Wedge-Shaped Chill Effectiveness

The effectiveness of the correctly designed wedge-shaped chill to produce soundness is demonstrated by the progression of the end-of-freeze isotherms at the bottom of Fig. 13. In the unchilled plate *A*, solidification started to develop near the riser while unsolidified metal still existed at a point further distant from the riser 6½ min after pouring started. The rate of solidification increased for a short distance in the longitudinal direction away from the end chill of plate *B*, but the chill did not promote lateral solidification.

Solidification was completed about 4 min after pouring started in plate *C*, but the longitudinal thermal gradients were nonexistent for a distance of about 1 in. immediately in front of the riser. In plate *D*, solidification at the riser-casting interface was completed 4 min after pouring started. The longitudinal thermal gradients at the end opposite the riser were high and carried through to the riser to produce a sound plate.

The results of these experiments showed that plates measuring 1 x 5 x 8 in. can be cast sound by using wedge chills of the correct design. Wedge-shaped chills must be designed to provide an impetus to the thermal gradients. This is achieved by using a taper in both the thickness and width of the chill.

Previous experiments with 2-in. thick plates showed that only a 6 x 10-in. plate of Al-7Mg alloy cast horizontally was radiographically sound when fed by an end riser located on the 10-in edge. For this reason, experiments were conducted with a 2 x 10 x 10-in. plate to demonstrate how its soundness is affected by wedge-shaped chills.

Plate *B* of Fig. 14 shows the arrangement of the four chills. The chills were 10 in. long, and tapered in width from 2½ in. to ⅛ in. They tapered in thickness from 2 in. at the wide end to 1 in. at the narrow end, positioned parallel in the drag.

Center Line Shrinkage

Radiographs of the plate showed that only a fine intermittent line of shrinkage existed in the casting.

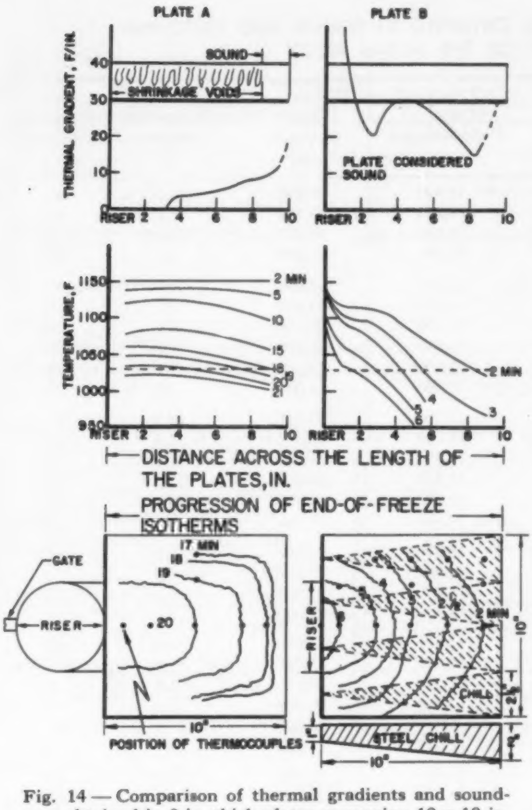

Fig. 14 — Comparison of thermal gradients and soundness obtained in 2-in. thick plates measuring 10 x 10 in. when wedge chills are placed along the length of the plate.

This center-line type of shrinkage extended from immediately in front of the riser to the opposite edge of the plate. The shrinkage occurred primarily between and above the two center chills and at a distance of about ¼-in. from the cope surface.

The thermal history of the plate was obtained from thermocouples embedded at the geometric center line of the plate. As shown in Fig. 14, large thermal gradients were present at the end of the plate opposite the riser. In front of the riser, however, the thermal gradients were from 5 to 8 F/in., close to the minimum required for soundness. Apparently the thermal gradients were below the minimum required for soundness in the vicinity where center-line shrinkage actually occurred which was ¾-in. above the geometric center line of the plate. Thermal gradients in this region could be increased, however, by chills with a still greater taper.

Again the effectiveness of the wedge-shaped chill in producing soundness is shown by a comparison of the thermal gradients present in an unchilled and chilled plate, plates *A* and *B*, respectively, Fig. 14. In the unchilled plate *A*, solidification started to develop near the riser while unsolidified metal still existed at a point farther distant from the riser. Solidification in this plate was not completed until about 20 min after pouring started. Solidification at the geometric center line in the chilled plate *B* was completed in about 6½ min after pouring started.

The results of these experiments show that the large thermal gradients and progressive directional solidification required to produce sound castings up to 2 in. thick can be obtained by wedge-shaped chills with a double taper. In everyday foundry practice, the general shape of the tapered chill can be approximated by using a series of button or spot chills which decrease in size as they approach the riser.

Comparison of Room Temperature Tensile Properties Obtained in Sound and Unsound 1- and 2-In. Thick Plates

When casting the Al-7Mg alloy, the feeding range of the riser decreases as the section thickness increases, which is contrary to what happens in casting steel. For example, a 1-in. thick plate of the aluminum alloy cast horizontally can be fed by an end riser for a distance of 5T, while a 2-in. thick plate can be fed for a distance of only 3T. Nevertheless, the experiments in the preceding sections of this paper show that the feeding distance in 1-in. thick plates can be extended from 5T to at least 8T by the use of wedge-shaped chills. Similarly, the feeding distance can be extended from 3T to 5T in 2-in. thick plates. The increase in feeding distance is the result of the large thermal gradients produced by the wedge chills.

The soundness of the plates cast from the Al-7Mg alloy has been based on radiographic examination. The acceptability of the plates and the methods used to achieve soundness should be reflected by the tensile properties of the plates. Therefore, plates were cast to determine whether an improvement in tensile properties does occur when wedge chills are used to extend the feeding range of a riser.

One- and 2-in. thick plates were cast with an end riser. The dimensions of the plates are listed in Table 2. Standard tensile specimens with a 0.505-in. reduced section were machined from coupons cut from the center line of the individual plates. The tensile properties obtained from these specimens are presented in Table 2 and Fig. 15. For purposes of comparison, the minimum and typical tensile properties obtained on separately cast test bars by one of the producers of commercial aluminum ingot are also given.

The average tensile strength and elongation obtained in the plates cast with wedge chills equaled or exceeded the minimum tensile properties obtained in separately cast test bars. The high properties of the chilled castings were attributed to the fine grain structure produced by the chills as well as to the high degree of soundness of the plates. It should be noted that neither manganese nor a grain refiner was added to the melts.

The data also show that the tensile properties for the unchilled plates decreased 1) as the section thickness increased (plates 1 and 4), and 2) as the feeding range of the riser was exceeded (plates 2 and 5). Thus, it is shown that tensile properties do reflect the soundness of the castings.

GATE LOCATION EFFECT

Experiments were conducted with 1- and 2-in. thick plates to determine whether the gate location has an effect on the thermal gradients and soundness of side-risered plates cast horizontally. Previously, the

TABLE 2 — ROOM-TEMPERATURE TENSILE PROPERTIES OBTAINED IN SOUND AND UNSOUND 1- AND 2-IN. THICK PLATES CAST OF THE Al-7Mg ALLOY

Plate	Plate Dimensions, in. Thickness	Length	Width	Sound	Specimen[a]	0.2 Per Cent Offset Yield Strength, psi	Tensile Strength, psi	Elongation in 2 in., %	Reduction in Area, %
1	1	5	5	Yes	1	15,400	32,200	12.3	14
					2	14,200	27,400	11.6	16
					3	13,500	28,700	14.3	15
					Ave.	14,400	29,400	13	15
2	1	8	5	No	1	13,100	24,000	9.7	11
					2	13,300	21,400	7.7	8
					3	14,200	24,100	8.5	8
					4	14,100	25,100	9.0	9
					5	15,000	25,500	9.5	14
					Ave.	13,900	24,000	9	10
3[b]	1	8	5	Yes	1	13,700	33,200	16.9[c]	20
					2	14,700	36,400	25.0	40
					3	14,400	35,800	22.0	26
					4	14,800	36,200	23.7	31
					5	15,900	37,800	19.1	25
					Ave.	14,700	35,900	21	28
4	2	6	10	Yes	1	14,200	24,500	8.3	11
					2	14,000	23,100	8.0	11
					3	15,800	27,300	10.4	15
					Ave.	14,700	25,000	9	12
5	2	10	10	No	1	13,400	23,600	9.0	11
					2	12,400	17,600	5.2	5
					3	12,500	18,500	6.3	7
					4	13,400	20,900	8.0	7
					5	—	24,900	10.3	17
					Ave.	12,900	21,100	8	9
6[b]	2	10	10	Yes	1	15,600	35,400	15.3	27
					2	14,700	33,200	18.8	28
					3	14,600	34,200	22.5	38
					4	14,400	35,400	26.2	32
					5	13,900	34,400	24.7	37
					Ave.	14,600	34,500	22	32
Minimum[d]							35,000	9	
Typical[d]							40,000	13	

a) Specimen 1 is in front of riser; Specimens 3 and 5 are at end opposite riser (Fig. 15).
b) Plates cast with wedge chills.
c) Broke outside gage marks.
d) Data obtained from "ALMAG 35" published by William F. Jobbins, Inc., Aurora, Ill.

gate had been connected directly to the side riser. In the present experiments the gate was attached to the edge of the plate opposite the side riser. The thermal history of the 1- and 2-in. thick plates (plates *B* and *C*, respectively) is presented in Fig. 16. Similar data obtained previously for a 1-in. plate gated directly into the side riser are included as plate *A*, Fig. 16, for comparison purposes.

Plates *A* and *B* measured 1x5x5 in.* From the thermal history of plate *B*, it was apparent that gating opposite the side riser increased the time of solidification to 10½ min as compared with about 6 min for plate *A* which was gated directly into the side riser. Although longitudinal thermal gradients were large in front of the riser of plate *B*, the lateral thermal gradients in front of the gate dropped below the 5 F/in. required for soundness. A small amount of center-line shrinkage along the length of the plate was revealed by radiography.

The second experimental casting (plate *C*) measured 2x6x10 in. Thermal gradients in this plate fell below 5 F/in. in front of the gate. Shrinkage was present throughout the plate as compared with only a small amount of center-line shrinkage in a similarly gated 1-in.-thick casting (plate *B*).

It was apparent that gating at the edge of a plate opposite the risered edge decreases the soundness of the plate. The decrease in soundness results from the localized heating of the sand in the vicinity of the gate. The heating of the sand, in turn, causes the thermal gradients in the plate to drop below the 5 F/in. required for soundness.

CUBES AND BARS OF Al-7Mg ALLOY CAST HORIZONTALLY

Investigations were conducted on cube and bar castings to 1) determine the feeding range of the riser, and 2) observe the effect that chills have on the thermal gradients and soundness of the castings.

The bars were cast horizontally. For all castings, the riser was located at one end, and the gate entered this side riser. The dimensions of the cube and bar castings and the riser that was used with each casting (giving length of cube and bar castings, and diameter and

*A plate of this size was radiographically sound when fed by a side riser to which the gate was attached.

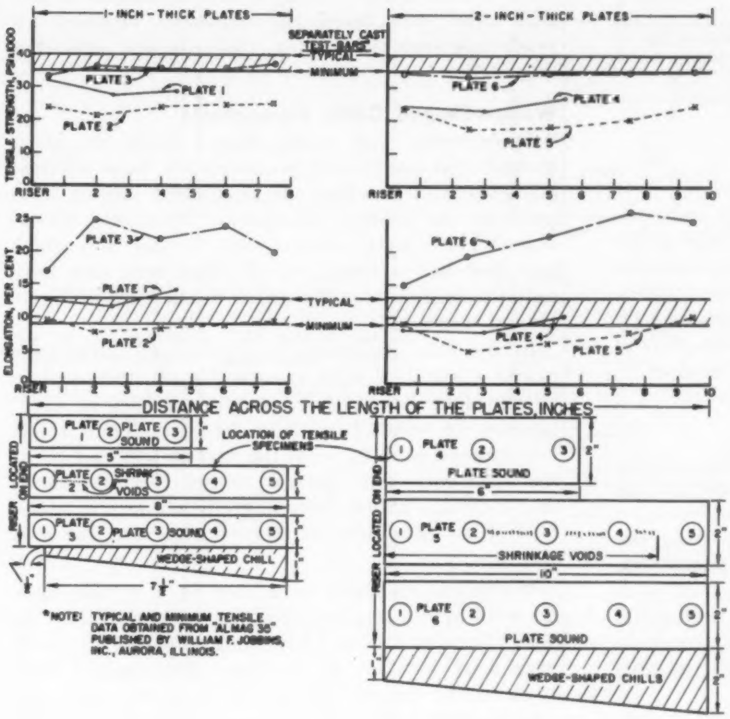

Fig. 15 — Comparison of room-temperature tensile properties obtained in sound and unsound 1- and 2-in. thick Al-7Mg plates.

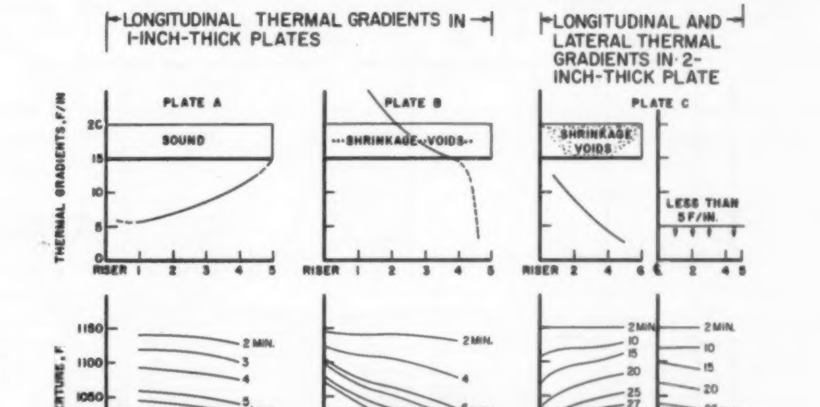

Fig. 16 — Effect on thermal gradients and soundness of changes in gate location in 1- and 2-in. thick plates fed by an end riser.

height of riser) are listed in the tabulation given below.

	Dimensions for Cube or Bar of Indicated Section Size, in.		
	2	3	5
Length of cube, in.	2	3	5
Length of bar, in.	8	12	—
Diameter of riser, in.	3	4½	7½
Height of riser, in.	5	5	5

The thermal history of the unchilled cubes is shown in Fig. 17. In the 2-in. cubes, the thermal gradients were never less than 5 F/in. The cube was radiographically sound. In the 3- and 5-in. cubes, thermal gradients were less than 5 F/in. and, as a result, they were unsound. These experiments showed that the feeding range of the riser is less than T for cubes with a cross-section greater than 2x2 in.

Cubes Tested

In previous experiments with plate castings, a chill placed at the end opposite the side riser increased the thermal gradients. The beneficial effect was restricted to a distance of about 1 T to 2 T away from the chill. To determine if a similar relationship exists for cubes, only the 2- and 3-in. cubes were cast with cube-shaped steel chills whose dimensions were equal to T. The chills were placed at the end of the cubes opposite the risers, as illustrated by the isotherm plots in Fig. 18.

The 2-in. cube was again sound, but small shrinkage voids occurred at the risered end of the 3-in. cube. The thermal gradients in both cubes were increased by the steel chill, and solidification was progressive from the chilled to the risered end of the cube. Nevertheless, lateral thermal gradients in the 3-in. cube were below the minimum required for producing soundness; hence, this cube was somewhat unsound.

Wedge-Shaped Chills Experiments

Experiments with wedge-shaped chills on plates showed that such chills produced the large thermal gradients, and provided the directional solidification necessary to achieve soundness. Therefore, wedge-shaped chills were studied with 2- and 3-in. thick bars that had a length of 4T. Bars were cast horizontally, as shown in Fig. 19, with the riser and gate located at one end.

In the first experiment, wedge-shaped chills were placed along the length at each side of a 2-in. square by 8-in. long bar (4T). The chills were 7½ in. long, tapering in width from 2 in. to ⅛-in. Their thickness tapered from ½-in. at the narrow end to 1 in. at the wide end. The thermal history (Fig. 19) shows that the longitudinal thermal gradients were in excess of 40 F/in. Radiographs showed that the bar was sound.

Wedge-shaped chills were used in a similar manner with a 3-in. square bar having a length of 12 in. (4T). The chills were 12 in. long, tapering in width from 3 in. to ⅛-in. In thickness they tapered from ¾-in. at the narrow end to 1½-in. at the wide end. The thermal history is also presented in Fig. 19, and shows that the longitudinal thermal gradients were lower than those in the 2-in. square bar. Large thermal gradients were present at the end opposite the riser,

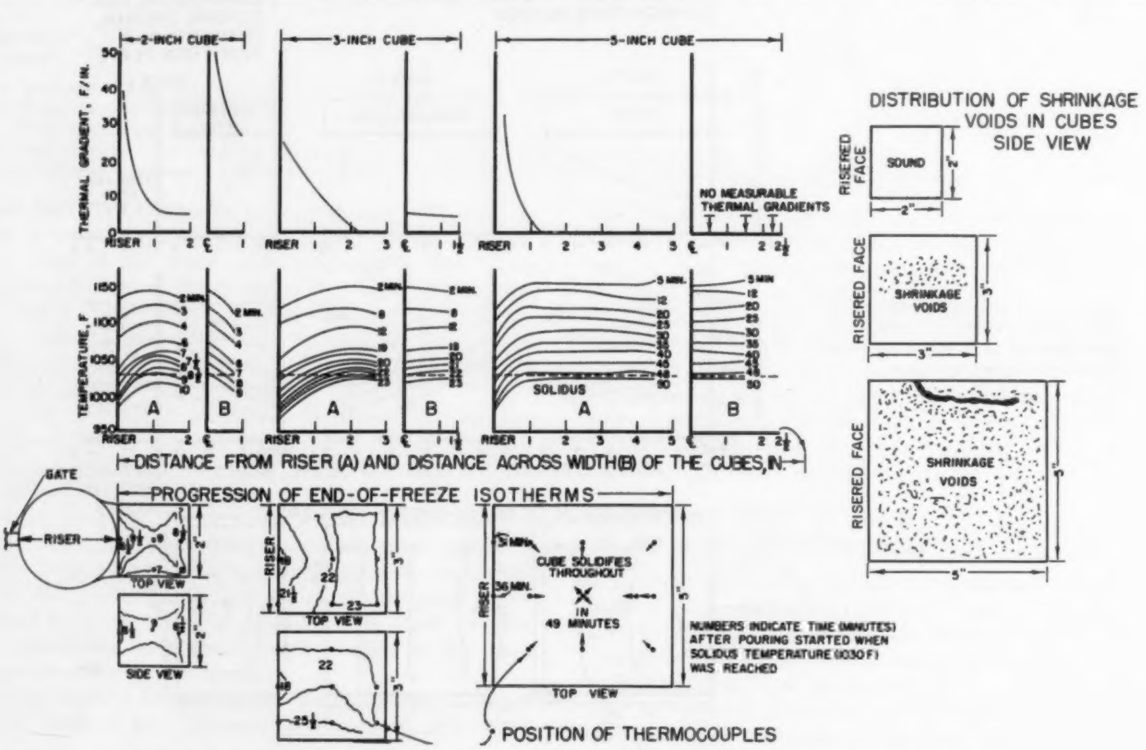

Fig. 17 — Longitudinal and lateral thermal gradients present at solidus temperature (1030 F) during the solidification of 2-, 3- and 5-in. Al-7Mg cubes fed by an end riser.

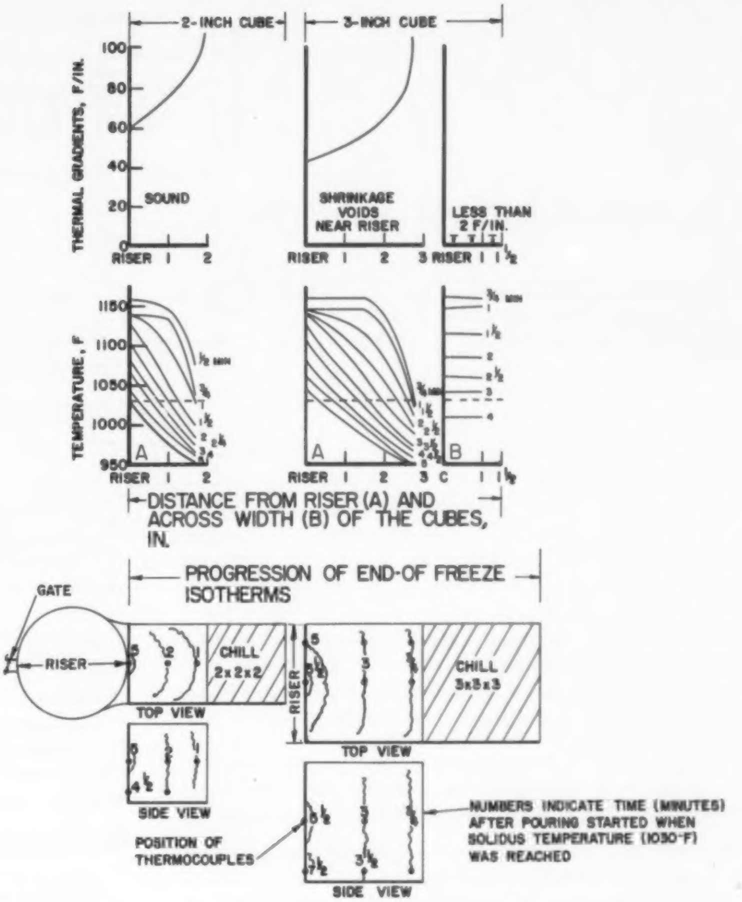

Fig. 18 — Longitudinal and lateral thermal gradients at solidus temperature (1030 F) during the solidification of 2- and 3-in. square chilled cubes of Al-7Mg alloy fed by an end riser.

but they decreased to about 30 F/in. in the middle of the bar. The thermal gradient immediately in front of the riser was only 15 F/in. Radiographs showed that this bar was sound.

These experiments reveal that 2- and 3-in. square bars with a length of 4T can be made radiographically sound with wedge-shaped chills. Thus, a method is available for producing soundness in 2- and 3-in. square bars beyond the normal feeding range of the riser.

CONCLUSIONS

The experimental work performed on plates and bars cast from the Al-7Mg alloy emphasizes that the development and maintenance of large thermal gradients throughout the plates and bars are extremely difficult. The gate as well as the riser and chills must be located correctly to create the large thermal gradients, and coordinated rate of directional solidification required for producing sound castings.

Horizontal Castings

The following observations were made from the experiments conducted with horizontal castings:

1) The feeding range of the riser in terms of T (the section thickness) decreases as the section thickness is decreased.
2) With a side riser, the length of plate found to be radiographically sound when expressed as a function of the plate thickness is as follows:

Thickness, in.	Length, in.
½	8T
1	5T
2	3T

3) Because the feeding range of the riser in terms of T decreases as the section thickness increases, additional risers rather than an increase in the size of the riser are required to produce sound castings.
4) When a top riser must be used on plates, increased soundness can be obtained by using multiple gates.
5) The feeding range in a square bar with a cross-section greater than 2 by 2 in. is less than 1 T.
6) A conventional steel chill placed at the end opposite the riser of cast plates or bars increases the thermal gradients, but the beneficial effect is restricted to the immediate vicinity of the chill. The end chill does not increase the feeding range of the riser.
7) Wedge-shaped chills with a double taper on the drag surface extend the feeding range in 1-in. thick plates from 5T to 8T. In plates 2 in. thick, the feeding range is extended from 3T to 5T.
8) Wedge-shaped chills with a double taper on op-

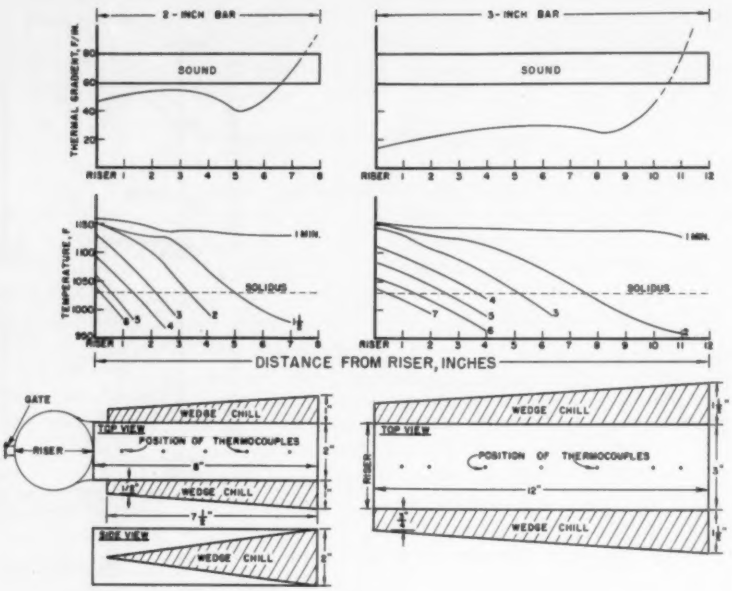

Fig. 19 — Longitudinal thermal gradients in 2- and 3-in. thick bars with a length of 4T, where *T* is the thickness of the bar.

posite sides of square bars increase the feeding range from 1T to 4T.

9) An insulated riser does not have a greater feeding range than an uninsulated riser.

The following principles of thermal dynamics were developed for locating risers, gates, and chills on castings of the Al-7Mg alloy to achieve soundness:

1) Thermal gradients in excess of 5 F/in. must be present to achieve soundness.
2) When the design of the casting permits, attach the riser to the side instead of the top of the casting.
3) When a side riser is used, attach the gate to it.
4) When a top riser must be used, employ multiple gates to obtain more uniform feeding.
5) To extend the feeding range of a riser, use wedge-shaped chills having a double taper. Place the chills so that directional solidification occurs toward the riser.
6) For a plate casting, the minimum thickness of the wedge chills at the wide end should be at least equal to the section thickness of the casting.
7) When the design of the casting permits wedge-shaped chills to be placed on both sides of a section, such as a bar, the thick end of the chill should equal at least one-half the thickness of that section.

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OPTIMUM CO_2 MOLDING

critical formulations of sodium silicate and sand

By Roderick J. Cowles

ABSTRACT

The difficulty of poor collapsibility, predominate as a limitation in the sodium silicate-CO_2 method of sand bonding, is obviated by establishing simple laboratory test methods to determine an optimum quantity of sodium silicate binder. This is designated as the minimum critical percentage for each sand considered. Additives such as sugar, coarse grain silica flour and iron oxide, properly used, contribute to the flowability, ramming qualities and green strength and enhance collapsibility as well as provide hot strength and cushioning during thermal changes.

The binder requirements should be developed on the hypothesis of adhesive bonding rather than on the basis of a mortar composition, which fills voids between the grains. Adhesive binders are most effective in thin films and with the greatest number of sand grain to grain adhesive contacts uniformly distributed in the sand structure. The viscosity and penetrating qualities of the binder composition determine the degree of correlation that binder requirements have to B.E.T. specific area measurements.

The B.E.T. data can be used to designate those sands which will need more or less binder than their AFS fineness number indicates. A straight line correlation between minimum critical percentage and a dimensional parameter calculated from AFS fineness data, shape factors, ratio multipliers and specific volume ratios raised to the fourth power is given.

The limitations due to high relative humidity and the use of clay additives are discussed. Experimental data, as well as numerous references, are used to support these findings.

INTRODUCTION

The problems of the sodium silicate-carbon dioxide method of bonding sand cores and molds have been recognized and enumerated in many references. A principle difficulty, collapsibility, is obviated in this work by establishing simple laboratory test methods to determine an optimum quantity of sodium silicate binder. This "minimum critical percentage" varies according to the foundry sand and the type of sodium silicate selected.

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The addition of 1.5 to 2.0 per cent sugar to the minimum critical percentage amount of binder establishes adequate green strength, and allows collapsibility with the addition of 0.4 up to 0.8 per cent sodium silicate beyond the minimum critical percentage amount. The proper choice of sodium silicate with enhancing additives such as sugar, silica flour and iron oxide can produce a composition of excellent ramming and flowing qualities. The many advantages for a foundry operation using properly formulated sodium silicate-CO_2 plus additive compositions more than offset the particular limitation of sensitivity to relative humidities above 76 per cent.

High ratios of silica to soda tend to retard this degradation, but for storage purposes the relative humidity should be controlled below approximately 70 per cent. Since the effect of moisture is reversible, any molds or cores air-dried before handling will regain their strength and surface hardness for normal foundry use.

Some sacrifice of other properties such as strength and surface hardness must be accepted when selecting high ratio silica to soda binders to assist in this problem of high humidity where the cores and molds can be used within a short time after gassing with CO_2. The preferred silicates used in relative humidities below 70 per cent have a viscosity range between 300 and 2000 centipoise, a ratio of silica to soda (between 2 to 2.4) to 1 and total solids of 43 to 47 per cent.

Sand Grain Contacts Adhesive

The sodium silicate, silica gel, sugar combination as the basic bonding material should be considered as an adhesive between sand grain contacts rather than a mortar composition filling voids between the grains. Such an adhesive is effective in thin films with the greatest number of small areas uniformly distributed as adhesive contact points in the sand structure. This accounts for a noticeable increase in gassed strength of cores and molds formulated with an addition of approximately 4 per cent of a coarse 90 to 140 mesh silica flour together with the recommended quantities of binder. Improved distribution of the binder

with a considerable increase in sand to sand contacts provides optimum use of the sodium silicate-sugar binder formulation.

Iron oxide aids collapsibility, provides hot strength during metal solidification and, due to a soda-iron oxide-silica eutectic composition at high temperatures, results in a smooth surface at the mold metal interface which prevents molten metal penetration.

This paper presents specific surface area data for various foundry sands. The B.E.T.* method used is a sensitive indication of differences between round smooth grain sands and those of angular rough surfaces. Highly adsorbent impurities will indicate greater surface areas than the proportional need for binder indicates; but this binder increase depends upon the viscosity and penetrating qualities of the binder composition. Although the binder requirements are not directly related to B.E.T. area differences, the specific area measurements can be used to designate those sands which will need more or less binder than their AFS number indicates.

Dimensional parameters of these sands are calculated from their AFS fineness data, together with their comparative specific volumes raised to the fourth power, and correlated in a straight line relationship with the minimum critical percentage requirement of a preferred sodium silicate binder for each sand.

Formulations for foundry molding of cores or molds by the sodium silicate binder-CO_2 setting method are recommended for the five sands which have been studied in this particular development approach. The formulations depend considerably upon the parameters of the sand which have been determined in their relation to the binder requirements.

THEORETICAL CONCEPTS FOR SILICATE BONDING

Sand size distribution for optimum structural properties in foundry molds has progressed measurably in the past 40 years.[1-11] The mold formation in most cases consists of a mortar-like bonding built up between the sand grains—a surface coating over the sand to retain permeability if possible, but adequate to capsulate and establish conforming structural units between the sand particles.[12] These bonding materials consist of inorganic-organic combinations such as water-clay-cereal flour and sea coal which contribute green strength as well as hot strength and form a cushioning effect between sand particles. Dietert[11] mentions that cushioning additives will eliminate or reduce mold wall fractures in such a bonded system.

*Method of evaluation devised by Brunauer, Emmett and Teller referred to later in this report.

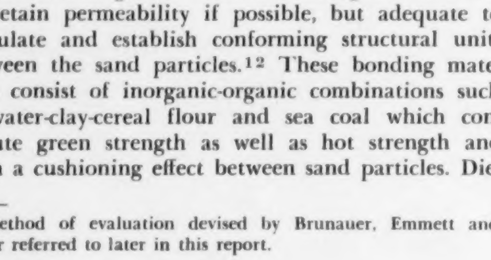


Fig. 1 — Left — Phenolic or sodium silicate bonding for sand molds and cores. Right — Normal clay bonding for sand molds and cores.

Foundry technology depends upon our knowledge of properly bonding sands or other similar refractory particles for handling prior to casting, and for retaining the metal as it solidifies without surface cracking or reacting with the molten metal. Dimensional stability of the mold mass is also important.[13]

There is then a difficult transition to accept new bonding concepts for foundry molds, and perhaps some of the requirements for optimum molding qualities are lacking. The nature of the sodium silicates requires a different approach; one which in many ways parallels that of phenolic resins in shell molding.[14] In either case, we should not expect the silicate or phenolic to act as a structural filling mortar between the sand grains. As a hypothesis, we must accept these bonding agents as adhesives between the closest surfaces of the refractory particles (Fig. 1).

Work of Adhesion

Sprinkle and Taylor[14] present valid data to substantiate the relation between strength or work of adhesion of the phenol-formaldehyde bond and shell mold tensile strengths. The science of adhesion, and its relation to surface wetting and intermolecular forces, is complex enough to establish many scientists as full time contributors in its continued study. Symposium papers[15] by Reinhart, Czyak, Kraus, Kemball, Bikerman, Blomquist, Koehn, W. S. Macfarlane and J. F. Sewell are only an indication of the many studies both fundamental and applied related to adhesives.

Once we make the assumption that we have an adhesive bonding system, the approach has been considerably established. Some fundamental concepts of adhesive technology should not be ignored in attaining better understanding of the sodium silicate bonded sand system.

A more detailed description of the physio-chemical properties of the sodium silicates themselves are given in a later section. Adhesive bonding considers five different phases or layers. These phases are solid, to surface layer, to adhesive, to surface layer, to second solid. If the bonding strength between any of these phases is weaker than the stresses locally applied, rupture of the adhesive bond follows. Of course, the sand surfaces themselves form the interlayer between solid and adhesive. Impurities on this surface layer as microscopic powders, such as clays and salts, may weaken the bond in this phase.

This surface layer between the solid and adhesive should give the least interference to optimum forces of molecular attraction. The mechanical surface construction of the sand is also important. Sand surfaces which are broken and contain cracks are subject to fracture under mold stresses. Smooth, clean surfaces provide best adhesive bonding with the minimum binder requirements. If the surface layer bond structure is strongest, the solids themselves or the adhesive may rupture. Mechanical impact, thermal stresses by shock or expansion may cause breaking of the solid sand material behind the surface interlayer.

In addition, the mechanics of the adhesive phase must be considered. The cohesive strength within the adhesive is dependent upon the uniformity, the thickness of the layer and the structural composition. The thinner and more uniform adhesive composition has the least probability of structural rupture.

Breaks in the bond can occur because of tensile stresses, shear stresses or impact stresses. The composition of the bond, the manner in which it is formed, the quantity and distribution of this bonding material, as well as the number of bond contacts, can produce a wide variety of physical strength values within the mold or core. Those combinations which give high tensile and compressive strengths may have bonds of poor flexibility and toughness. A combination of these properties is most desirable.

A sand adhesive bond structure may have high compressive strength and poor resistance to surface rubbing or foundry washing. This point is substantiated by data (Table 2, experiments 251, 327, 324, 326; Table 3, experiment 118C,) where it is noted that compressive strengths do not correlate with surface hardness results.

EXPERIMENTAL STUDIES RELATED TO SILICATE FORMULATIONS

Simple procedures of evaluating sodium silicate bonded, CO_2 gassed-sand formulations by forming and testing laboratory cylinder specimens has enabled a comparatively comprehensive correlation of numerous interrelated variables. Plant trials and proven production formulations have substantiated many of these experimental findings. The first laboratory and plant run experiments provided a basis for the more comprehensive studies which followed, and are presented here.

Accepting the hypothesis of adhesive bonding, and the many published variations of sodium silicate compositions for consideration, the experimental possibilities become uncountable. A selection of conditions and the limits for their variation must be made initially to keep the quantity of experimental studies at all reasonable. Even with this screening approach thousands of specimen were tested.

It was established that any of the properties such as:

TABLE 1 — SOME FORMULATION STUDIES WITH CYLINDER CORE SPECIMEN USING AFS 105 SAND CODE D

Exp. No.	Silicate Binder Used, No.	Binder, %	Additives, % Sugar	Water	Iron Oxide	Silica Flour	Other	Compressive Strength, (psi) Before Heat	After Heat	Dietert Surf. Hardness Before Heat	After Heat	Relative Humidity, %	Comments
173	1	3.7	2.0	0.5		4.0		550	110	83	66	Room	Poor collapsibility
173	1	3.7	2.0	0.5		4.0		3	154	30	71	88	
174	1	3.0	2.0	0.5				500	1	77	45	56	Excellent strength and collapsibility
174	1	3.0	2.0	0.5				2	2	0	57	88	
A2AO(10)	1	2.5	2.0					400	2	85	Low	Under 60	
A2AQ(8)	1	2.5	1.0					380	2	78	Low	Under 60	
A2AQ(9)	1	3.0	1.0					628	2-200	84	0-70	Under 60	Variable collapsibility
7/29/57	1	3.0	2.5					360	80	82	0-60	Under 60	
A2AQ(11)	1	3.0	2.0					150	2-125	88	0-65	Under 60	
236	1	3.5	2.0					400	20	88	32	34	Excellent
237	1	4.0	2.0					390	75	92	40	34	Very good, but may have problems of collapsibility
238	1	5.0	2.0	0.5				140	143	84	45	72	Poor collapsibility at higher humidity
238A	1	5.0	2.0	0.5				592	0	89	0	40	Excellent at lower humidity
250	1	3.0	2.0	0.5			*0.2	510	0	80	0	40	Stand 28 days, excellent results all around
160	8	4.0	2.0	0.5				35	0	92	0	46	Inadequate strengths due to binder difference
160	8	4.0	2.0	0.5				9	0	68	0	88	Inadequate strengths due to binder difference
160A	8	3.0	2.0	0.5	2.0			10	0	88	0	Room	Inadequate strengths due to binder difference
160A	8	3.0	2.0	0.5	2.0			3	0	48	0	88	Inadequate strengths due to binder difference
160B	8	5.0	2.0	0.5	2.0			9	0	90	0	Room	Inadequate strengths due to binder difference
160B	8	5.0	2.0	0.5	2.0			18	0	77	0	88	Inadequate strengths due to binder difference 160B dries out quickly
160C	8	7.0											No good, not workable
171	8	4.5	2.0			4.0							Too sticky
171A	8	3.5	2.0			4.0		100	0	93	0	68	Fair surface
171A	8	3.5	2.0			4.0		14	0	61	0	88	Poor, due to high humidity
176	8	3.5	2.0					158	0	87	0	50	Good surface

*Cresol-phenolic organic derivative

After Heat—2200 F for 5 min

TABLE 2 — SOME FORMULATION STUDIES WITH CYLINDER CORE SPECIMEN USING SUB-ANGULAR AFS 70 CODE B

Exp. No.	Silicate Binder, No.	Binder, %	Additives, % Sugar	Water	Iron Oxide	Silica Flour	Other	Compressive Strength, psi Before Heat	After Heat	Dietert Surf. Hardness Before Heat	After Heat	Flow-ability (Dietert)	Rel. Hum. %	Comments
203	1	2.0						95	2	53	47		Normal	Poor rub resistance,
203	1	2.0						2	2	7	42		88	good surface
204	1	2.5						77	15	56	57		Normal	Good surface, flowable
204	1	2.5						5	20	0	63		88	mix
205	1	3.0						110	170	62	68		Normal	
205	1	3.0						29	140	0	75		88	
337	1	1.5						6	0	8	0	85	100-44	Very dry, very poor surface
338	1	4.0						500	300	74	74	84	100-44	Excellent surface, poor collapsibility
206	1	2.0	2.0	0.5		4.0		183	2	84	52		40	
206	1	2.0	2.0	0.5		4.0		2	2	0	55		88	
207	1	2.5	2.0	0.5		4.0		200	22	88	56	85	40	Good except for humidity resistance
207	1	2.5	2.0	0.5		4.0		2	18	0	59		88	
207	1	2.5	2.0	0.5		4.0		263	32	85	67		52	Nov. 21, 1958
264	1	2.5	2.0	0.5		4.0		65		79			56	After 48 hr
230	1	2.3	2.0	0.5		4.0		220	40	87	63		62-74	Excellent all-around cores
230	1	2.3	2.0	0.5		4.0		2	50	10	60		88	Collapsibility not too good, low strength
236	1	3.5	2.0					400	20	88	32		86-34	Excellent mix and surface
251	1	3.0	2.0					340	0	57	0		40	Stand 29 days
262	1	3.0	2.0						90		81		56	2600 F and 2800 F
252	1	2.5	2.0	0.5	2.0	4.0		400	0	80	0		52	Stand 18 hr (good)
263	1	2.5	2.0	0.5	2.0	4.0		100	0	82	4		56	Stand 48 hr (good)
323	2	2.4	2.0					59	2.5	48	30		40-55	
323	2	2.4	2.0					19	2.5	5	30		88	Soft and soggy
327	2	2.4	2.0	0.5				188	Not Tested	37	Not Tested		40-55	Note
327	2	2.4	2.0	0.5				6	Not Tested	1.2	Not Tested		88	Soft
324	2	3.0	2.0					288	112	52	55		40-55	
324	2	3.0	2.0					219	112	57	55		10-30	Note
324	2	3.0	2.0					2.5	112	2	55		76-88	
325	2	3.6	2.0					225	Not Tested	50	Not Tested		40-55	Note
325	2	3.6	2.0					19	Not Tested	10	Not Tested		88	Soft
326	2	3.6	2.0	0.5				344	Not Tested	52	Not Tested		40-55	Note
326	2	3.6	2.0	0.5				12	Not Tested	10	Not Tested		88	Soft
341	2	6.0	2.0					600	420	84	82	82	55	Stand 48 hr, poor collapsibility
215	8	2.5	2.0			4.0			65					Too sticky to remove
216	8	3.0	2.0				3		33				80	Too sticky
217	8	3.0	2.5			4.0	145*	0	82	17		83	63	Sticky *compressive strength (Dietert)
217	8	3.0	2.5			4.0	2	0	17	17			88	
231	8	3.5	2.5			4.0	220	2	92	26			45	Dries fast
231	8	3.5	2.5			4.0	3	2	38	38			88	
287	8	3.2											46	Not workable
313	8	2.5	2.0	0.5	2.0	4.0	62	0	64	0		80	55	(More binder necessary for strength) No. 8 is a questionable binder for this sand

NOTE—All samples allowed to stand minimum of 5 hr at room conditions, then in desiccator for a minimum of 5 hr.
*Cresol-phenolic organic derivative.

a) Compressive strength.
b) Surface hardness.
c) Collapsibility with heat.
d) Ability to flow and ram into a uniform smooth load supporting core or mold surface.
e) Part cleanly from the casting, would depend most upon the variations of:
   1) Characteristics of the sand selected (see detailed discussion).
   2) Type and quantity of sodium silicate used as the binder (see description of sodium silicate binders).
   3) Additives used. Favorable ones include, 90 to 140 mesh silica flour, syrup or sugar, iron oxide, in some cases water, and a cresol phenolic organic powder used in small quantities; of controversial value are selected clays, pitch, sea coal and cereal.
   4) Relative Humidity. Structural strength and surface hardness are reduced considerably by humidities above 76 per cent. The effect of moisture is reversible, however, and the favorable properties lost by exposure to high humidity are regained in dry conditions, accelerated by oven drying if desirable.
   5) Gassing. Equipment method; quantity, rate and

TABLE 3 — SOME FORMULATION STUDIES WITH CYLINDER CORE SPECIMEN USING ROUND GRAIN OTTAWA SAND, CODE A

Exp. No.	Binder Used, No.	Binder, %	Additives, %					Compressive Strength, psi		Dietert Surf. Hardness		Flowability (Dietert)	Relative Humidity, %	Comments
			Sugar	Water	Iron Oxide	Silica Flour	Other	Before Heat	After Heat	Before Heat	After Heat			
104	1	1.5						279	132	75	72		Below 60	Smooth surface Dries fast
105	1	1.0						40	0				Below 60	Poor cores
106	1	2.0						361	628	77	87		Below 60	Poor collapsibility
346	1	1.8						48	54	53	47		50	Good surface, R.H. 25% when made
111	1	1.25	1.0	0.25				138	0	86	0		Below 60	Poor cores
118	1	1.8	1.5	0.375				283	14	82	57		Below 60	Smooth surface
118	1	1.8	1.5	0.375				585	8	85	65		Below 60	
118B	1	1.8	1.5					470	3	60	50		Below 60	
118C	1	1.8	2.0					612	2	41	23		Below 60	Mix dries rapidly
119	1	1.8	1.5	0.375				251	4	80	59		Below 60	Usable formula
119A	1	1.8	1.5	0.375				203	8	70	53		Below 60	lower limit of sugar
121	1	1.8	1.5	0.375				628 +	2	78	51			Cores dried in oven
121C	1	1.8	1.5	0.375				337	50	74	77		52	Repeat of 121 with CO_2
120	1	1.8	2.0		2.0			558	0	70	0		24	Good results but surface hardness
120A	1	1.8	2.0		2.0			628 +	0	60	0		28	Too low
122	1	1.8	2.0	0.5	2.0			538	0	89	0	82	38	Selected as an excellent formula
126	1	1.8	2.0	0.5	2.0			550	0	80	42		30	
126	1	1.8	2.0	0.5	2.0			10	0	33	40		76	
133	1	1.8	2.0	0.5			Fire Clay 2.0	465	0	90	55		55	Fair cores
134	1	1.8	2.0	0.375	2.0		*0.25	327	0	80	0		29	Good results
136	1	1.8	2.0	0.375			*0.25	351	2	63	38		31	Surface hards needs
137	1	1.5	2.0	0.375			*0.25	426	6	68	0		35	improvement
138	1	1.8	1.5	0.375	2.0		*0.25	628 +	0	71	0		35	
161	1	1.8	2.0	0.33			*0.2	300	12	63	3		46	
161	1	1.8	2.0	0.33			*0.2	3	3	8	10		88	
167	1	2.5	2.0	0.5	2.0	4.0		628	60	95	72		42	Excellent, very smooth,
167	1	2.5	2.0	0.5	2.0	4.0		100	185	43	74		88	good detail, see standard and 336
Standard	1	2.4	2.0	0.5	2.0	4.0		628 +	51	90				Excellent
168	1	1.8	2.0	0.5			$Ca(OH)_2$ 6.0	212		80			Room	Poor surface, too many
168	1	1.8	2.0	0.5			6.0	108					88	lumps, heat given off
258	1	3.5	2.0		2.0	4.0		628 +	94	82	75		25-45	Questionable collapsibility
258A	1	1.8	2.0	0.5	2.0	4.0		592	6	82	30		25-45	Excellent results
258A	1	3.5	2.0	0.5	2.0	4.0		628 +	425	87	70		25-45	Poor collapsibility
253	1	1.4	2.0					80	0	69	0		10-30	Sample placed in desic-
253	1	1.8	2.0					90	70	65	55		10-30	cator immediately
253	1	2.5	2.0					125	188	83	69		10-30	Poor collapsibility
253	1	3.5	2.0					430	220	72	79		10-30	Sample stood 5 hr before desiccator, poor collapsibility
256	1	1.8	2.0			4.0		130		54			10-30	
256	1	3.5	2.0			4.0		628 +	462	88	88		10-30	Poor collapsibility
255	1	1.4	2.0					215	0	46	0		40-55	Low surface hardness
255	1	1.8	2.0					262	25	50	40		40-55	
255	1	2.5	2.0					331	100	59	71		40-55	Poor collapsibility
255	1	3.5	2.0					462	230	65	72		40-55	
340	1	6.0	2.0					628 +	628 +	95	100		40-55	
257	1	1.8	2.0			4.0		91	0	60	0		40-55	
257	1	3.5	2.0			4.0		628 +	417	88	81		40-55	Poor collapsibility
339	1	2.7	2.0			4.0		550	67	78	56		40-55	Acceptable results
136A	1	1.8	2.0	0.5				467	78	81	71		52	
122D	1	1.8	2.0	0.5	2.0			487	0	84	0		52	Good results
156	8	3.5	2.0	0.5				80	0	82	32		45	Poor surface
156	8	3.5	2.0	0.5				30	2	53	27		88	
158	8	2.5	2.0	0.5	2.0			180		93			45	Good all-around core
158	8	2.5	2.0	0.5	2.0			10		50			88	
158A	8	2.5	2.0	0.5	2.0			180	0	93	0		45	
158A	8	2.5	2.0	0.5	2.0			11	0	61	0		76	
159	8	2.5	2.0	0.5		4.0		275	3	93	45		50	
159	8	2.5	2.0	0.5		4.0		**30	3	69	45		88	
162	8	2.5	2.0	0.33			*0.2							Impossible to remove from core box
163	8	2.5	2.0		2.0			450	0	95	0		45	Good surface
163	8	2.5	2.0		2.0			23	0	40	0		88	
164	8	2.5			2.0									Dries too rapidly, no good

(continued on next page)

TABLE 3 — CONTINUED

Exp. No.	Binder Used, No.	Binder, %	Additives, %: Sugar	Water	Iron Oxide	Silica Flour	Other	Compressive Strength, psi: Before Heat	After Heat	Dietert Surf. Hardness: Before Heat	After Heat	Flow-ability (Dietert)	Relative Humidity, %	Comments
165	8	2.5	2.0		2.0	4.0		628 +	0	90	0		47	Excellent formula, see 159, 172, and 218 Excellent cores
165	8	2.5	2.0		2.0	4.0		*73	0	58	0		88	
166	8	2.5	2.0	0.5	2.0	4.0		518	0	94	10		38	Fair surface, good formula
166	8	2.5	2.0	0.5	2.0	4.0		**25	0	63	0		88	
157	6	2.5	2.0	0.5				500	0	80	40		45	Good
157	6	2.5	2.0	0.5									88	No good, no strength

*Cresol-phenolic organic derivative.

**Show some resistance to high humidity.

time of distribution into the piece gassed. Extent of gelling versus drying by CO_2 or other gases.

and to a lesser degree the following require control:

1) Mixing, methods and time.
2) Storage time of mix.
3) Storage time of gassed piece.
4) Method of forming core or mold.
5) Temperature at the time of mixing, gassing and storage.

The standardization of most conditions which would cause variance allowed a more specific study of those variables which are most important. These are considered:

a) Variations of sand.
b) A determination of optimum choice of sodium silicate binder.
c) An attempt to reduce the deleterious effect of high relative humidity by the use of additives or sprays.
d) The establishment of additives which can assist and enhance the binder properties of the sodium silicate.
e) The effect of controlled water addition to the original mix related to the sand silicate system used.

Minimum Critical Percentage of Sodium Silicate

Early in the experimental work, together with information from outside technologists in this field, it seemed apparent that additives such as clay, pitch, sea coal and foundry syrup contributed to better collapsibility, but simultaneously reduced the bonding values of the sodium silicate used. The laboratory evaluation method uses cylinders of various formulation heated to a high temperature such as 2200 F for a determined time in a muffle furnace. After cooling, the compressive strength of these cylinders seems a good indication of core collapsibility in plant operations.

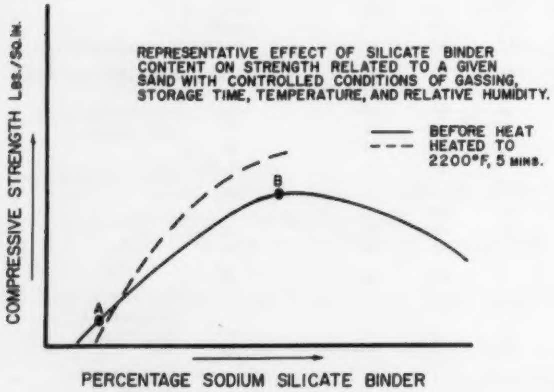


Fig. 2 — Typical curve for compressive strength related to weight percentage of sodium silicate used.

Weight Per Cent of Sodium Silicate

Figure 2 shows a typical curve, some of which have appeared in the literature, for compressive strength related to weight percentage of sodium silicate used.[16,17] The solid line represents the strength of the core or mold before metal is poured. Point *B* would appear to be the optimum amount of sodium silicate to give best surface hardness and handling strength. We have to drop back to point *A* on the curve, however, to obtain low strength after heating, in other words, attain collapsibility. Increased amounts of sodium silicate beyond this point only increase the glass bond at high temperatures resulting in a hard ceramic formation, shown as the dotted line.

In agreement with the discussion concerned with the theory of adhesives, it was realized that there is an optimum quantity and adhesive film thickness for each sand under consideration. The number of contacts between sand grains contributing structural strength is also important.

Work with the optimum quantity *B* of sodium silicate requires moving the dotted line a considerable distance to the right to assure good collapsibility. This requires additional quantities of modifying binder materials such as clay and aluminum oxide resulting in only reduced strength for handling the initial cores or molds. The studies have shown that the best approach was to consider the quantity *A* of sodium silicate binder, which we will call the minimum critical percentage of sodium silicate, which gives some strength and yet allows collapsibility.

Figure 3 shows such curves with no additives used for five different sands. The differences in silicate binder requirements and the resulting collapsibility among various sands is quite marked. The physical characteristics of the sand in measurable parameters is most important in considering sodium silicate

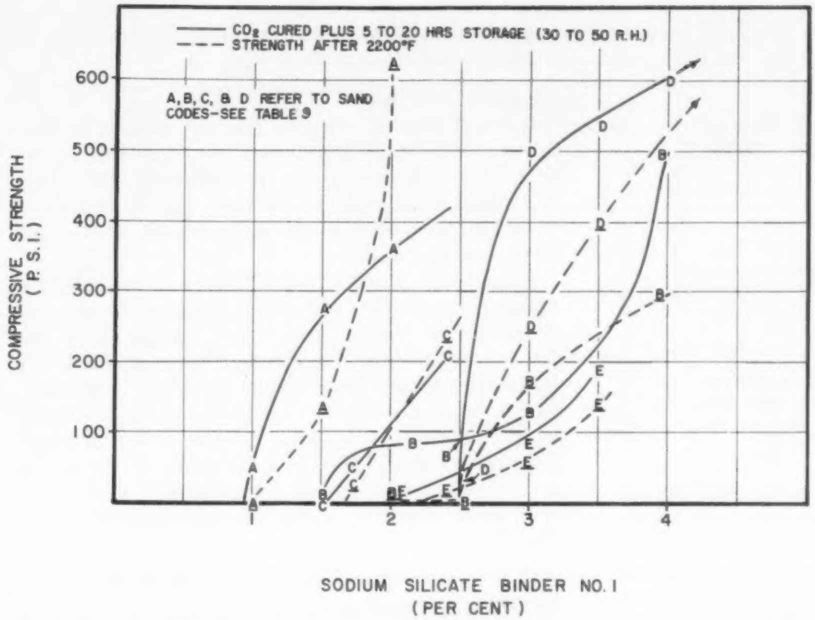


Fig. 3 — Relationship between compressive strength and per cent silicate binder (no additives) for five different sands, before and after high temperature.

bonding formulations (Table 9). The number of bond contacts, the area of these contacts and the condition of the sand surface are apparently most important, and substantiate the concepts of bonding presented here.

Additives

The favorable additives listed previously used in reasonable percentages will add considerably to the strength, ramability and surface hardness if used with the lower *A* percentage of a sodium silicate such as no. 1 which is a 2 to 1 ratio silica to soda, 45 per cent total solids, 51 degree Baumé, or the *A* amount plus approximately 0.5 to 1.8 per cent more silicate depending on the sand silicate system. Both sugar and iron oxide assist the collapsibility allowing the additional amount of binder above Point *A*. Consider Figure No. 4 using the round grain sand Code No. A and the no. 1 silicate binder.

The critical percentage of sodium silicate in this system is about 1.1 per cent. The addition of 2 per cent sugar, as well as the addition of 2 per cent sugar with 4 per cent of a coarse 90 to 140 mesh silica flour, moves the collapsibility curve almost 1 per cent silicate to the right. Figure 5 presents convincing evidence of the additional value of adding 2 per cent iron oxide and ½ per cent water. Water addition should be made with care, since the dilution of sodium silicate can result in apparently good initial gas strength but reduced strength with storage. In this case, however, the water seems to enhance the value of the sugar silicate adhesive system.

The value of adding silica flour depends upon the

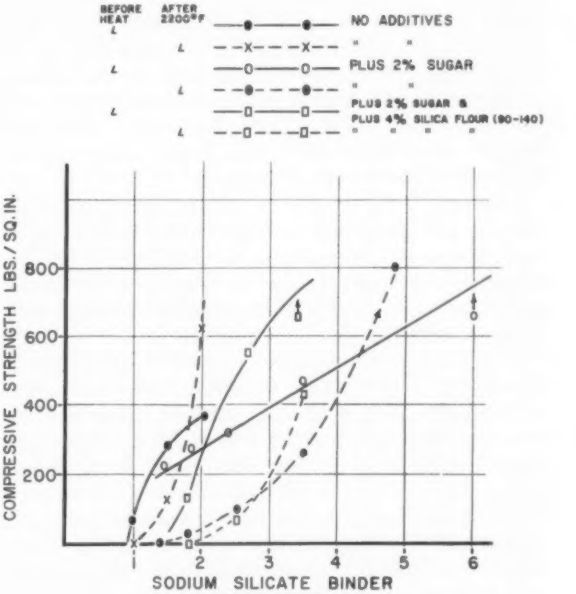


Fig. 4 — Effect of adding sugar and silica flour on strength and collapsibility of a single sand-silicate binder combination (sand A and Binder No. 1).

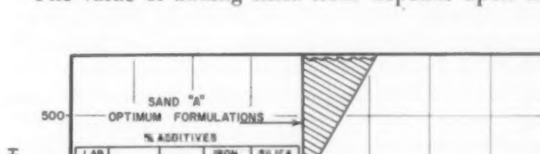


Fig. 5 — Evidence of the additional value of adding 2 per cent iron oxide and ½ per cent water.

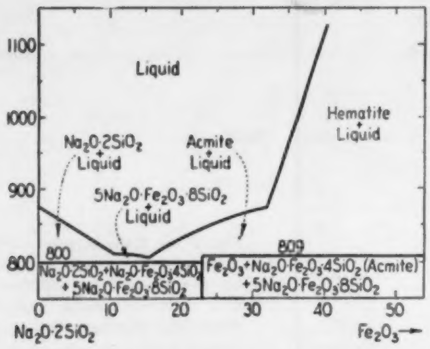


Fig. 6 — Phase diagram showing the possible compositions depending upon percentages of ingredients included and temperatures (deg. Cent.) considered.

particle distribution system of the sand used. Fine silicate flour such as 325 mesh in most cases will reduce the properties of the bond rather than enhance them. The coarser flours on the other hand act as building blocks between the sand grains increasing the number of adhesive bonded contacts.

The silicate without sugar is either too weak in the quantities we recommend for proper collapsibility after metal pour, or becomes brittle with poor properties of toughness. The tensile or compressive strength, however, in an all silicate bond can be quite high especially if the quantities are excessive compared with the recommended minimum critical percentage. Such a bonding adhesive, however, develops many stresses as the silicate dries out and shrinks pulling away from the sand contacts.

This more rigidly bonded structure is in direct opposition to the argument for cushioning additives such as sugar, which eliminate mold and core surface fractures. The sugar contributes strength allowing a lower amount of sodium silicate, and initially retains moisture which contributes to the flexibility and toughness of bond structure.

Clay

Additives such as clay interfere with the chemistry of the silicate bond, and must be used with care because they agglomerate in such a high pH (highly alkaline).[30] Experimental plant trials are evidence that clay may be used to produce fairly satisfactory castings. The results are spotty, however, with poor collapsibility predominate, and indicate the difficult problems of control in a questionable system. However, iron oxide as a powdered additive is evidently compatible with a sodium silicate system and becomes a favorable part of the adhesive bond. Its greatest values, however, are added flowability in forming a uniform mixture, and enhancing the collapsibility which allows the additions of a few tenths per cent silicate with the sugar-silica flour formulation. Iron Oxide also acts with the molten metal to form an iron oxide-soda-silica complex which prevents metal penetration, retards core cracks at the high temperatures of metal pour and adds to the smoothness of the casting.[31,32] The phase diagram of Fig. 6 shows the possible compositions depending upon percentages of ingredients included and the temperatures (deg. cent.) considered. Liquids, eutectics and solid mixes are designated.

Organic Additive

A cresol phenolic organic additive is used in these formulations in small amounts not to exceed 0.2 per cent. It has enhanced the ramability of the mixes, and appears to form just enough gas at the metal-mold interface and results in a smooth, almost polished, casting surface.

As shown in Fig. 5, these additives all contribute to better collapsibility, and allow additions of more sodium silicate binder (from 0.5 to 1.5 per cent) than the minimum critical percentage allowed. Even with optimum additive formulations, however, as shown in Fig. 5, there is a binder quantity limit beyond which poor collapsibility becomes evident. An example is experiment 256, Table 3. Each sand, of course, has its own minimum critical percentage of silicate as a base from which to formulate, previously shown in Fig. 3.

Silica Sand — The Physical Variations Related to Silicate Bonding

The first laboratory and plant investigations of the sodium silicate-CO_2 cured process repeatedly emphasized the inability to formulate with a variety of different sands to attain acceptable molds and cores. It seemed important at this time to study the properties of the sand related to bond requirements considering the sodium silicate as an adhesive bonding system. The work was carried out in two approaches simultaneously, correlating the results wherever possible. The first is the laboratory evaluation method which was devised using cylindrical cores with all variables controlled including one selected sodium silicate bonding material, but varying the quantity used with the type of sand being evaluated.

Figure 3 is an example of plotted data determined by this approach. A code description of these sands is given in Table 9 and includes data established by the second approach, that of measuring all the known parameters of the sand and obtaining numerical comparisons where possible. There has been a fairly successful correlation of the silicate binder needs and the measured characteristics of the sand.

Arbitrarily, the minimum critical percentage was taken as the percentage of binder no. 1 with no additives which will contribute approximately 100 psi compressive strength to the test cylinders, simultaneously not exceeding a collapsibility strength after heating at 2200 F of approximately 60 psi.

It was impossible to meet this latter requirement in the case of sand *C*, since its collapsibility follows almost parallel and equal to its strength before heating. This sand was recommended as satisfactory by other users, but because of these data sand *B* similar in description but with a collapsibility after heat curve considerably below the strength before heat curve is recommended by preference. Sand *E*, which has a high AFS number, has a problem of the collapsibility curve following closely the before heat curve. Figure 5 shows how additives are used to separate these two curves for any sand binder combination.

This is accomplished, however, much more easily

TABLE 4 — SOME FORMULATION STUDIES WITH CYLINDER CORE SPECIMEN USING FINE GRAIN SUB-ANGULAR SAND, CODE E

Exp. No.	Silicate Binder Used, No.	Binder, %	Additives, %				Compressive Strength, psi		Dietert Surf. Hardness		Flowability (Dietert)	Relative Humidity, %	Comments
			Sugar	Water	Iron Oxide	Silica Flour	Before Heat	After Heat	Before Heat	After Heat			
169	1	3.0	2.0	0.5			212	68	92	80		Room	Good surface, poor col-
169	1	3.0	2.0	0.5			4	125	51	78		88	lapsibility potential
A1AQ(13)	1	2.5	2.0						45	27-52			Low strength
275	1	1.5											Too dry
349	1	1.8	2.0	0.5	2.0	4.0	271	0	70	0		50	Good surface
271	1	2.0											Too dry
272	1	2.5					50	0	66	0		41	
348	1	2.5		0.5			12	3	77	68	82	50	Fair surface
306	1	2.5	2.0	0.5	2.0	4.0	250	56	70	0		55	Usable for operation
273	1	3.0					92	67	79	70		41	Sticks slightly
274	1	3.5					196	150	85	70		41	Hard to work with
350	1	3.5	2.0	0.5	2.0	4.0	258	144	82	70		50	Excellent surface
276	8	3.0											Not workable
277	8	3.5											Not workable
278	8	4.0											Very fragile
170	8	4.5	2.0				163		94			Room	Difficult to remove
170	8	4.5	2.0				80		80			88	from mold

with some sands than with others. The strength before heat curve is raised considerably at any given percentage binder, and the collapsibility curve is reduced moving to the right and requiring higher percentages to show the undesirable strength after heat. Sand *A* is a well distributed round grain sand that has a low specific surface and appears ideal for the sodium silicate-CO_2 cured system.

Noncontrolled Addition Effect

Promiscuous addition of sodium silicate to such a sand can cause difficulty in collapsibility and hot casting cracks, because the mold cannot crush or move to accommodate shrinkage of the metal.[11,13] Using a well controlled percentage of sodium silicate together with additives, such as sugar and iron oxide, hot rigidity of the mold is reduced, obviating problems of hot casting cracks, rattail and buckle.

Sand *E,* on the other hand, with a high AFS fineness number of 158, a five screen distribution and a measured low-packed density, evidently would tend to reduce the contacts for adhesive bonding and indicate a desire to add greater amounts of silicate for bonding strength.[9,10] However, as the curve in Fig. 3 shows, the strength is raised only slowly with the addition of more silicate.

Experimental studies, Table 4 experiments 349, 306, and 350 substantiate the belief that coarse flour 90 to 140 mesh addition to such a sand as sand *E,* filling in the voids and greatly increasing the number of bond contacts, enhances the use of this sand for the CO_2 molding process. Due to limited experimental time the optimum addition of silica flour for sand *E* has not been determined. The following formula is proposed—3½ per cent no. 1 silicate binder, 2 per cent sugar, ½ per cent water, 2 per cent iron oxide and 8 per cent silica flour 90 to 140 mesh.

Although sand *D* is a controlled three screen sand, it contains considerable impurities mostly of a micaceous nature, which because of its laminate form has an excessive specific surface, this being unit area per unit weight presented as sq cm/gram.[6,7,8] The addition of silica flour to sand *D* does not improve the bond contacts. The micaceous inclusions evidently interfere with this possibility and otherwise contribute in this respect.

The method of calculating specific surface by the use of sieve analysis is well presented.[2] For clean washed sands, and using proper ratio multipliers dependent on the type sands—round grain, sub-angular and angular, these methods seem quite comparable and indicative of the actual specific surface.

Laboratory Methods

There are other highly developed laboratory methods, however, which measure the amount of gas in molecular layers, such as argon, adsorbed on all parts of the surface of any powdered material. This method devised by Brunauer, Emmett and Teller called the B.E.T. method was used as a further evaluation on these five sands for comparative specific surface area.[8] Sand *D,* Table 9, has a considerably higher B.E.T. specific surface compared with its sieve analysis evaluation for specific surface, 810 sq cm compared with 315.

This comparison is reversed in the case of sand *E* where specific surface calculated by sieve analysis shows 432 sq cm/gram, and the B.E.T. Method 152. Sand *A* shows such a low specific surface by the B.E.T. method that it approaches the area of perfect spheres. These anomalies show the difficulty of using any one measured parameter for comparing one sand to another to predict foundry binder requirements.

In addition the minimum critical requirements of various sodium silicates for each of these different sands add to the further knowledge of their properties. Using a low viscosity 60 centipoise silicate such as no. 8 (Table 10), it is almost impossible to attain good strengths by using additional quantities of this silicate with *D* sand which has a high adsorptive power because of its micaceous inclusions. On the other hand, sand *D* can be bonded with reasonable quantities of a viscous binder of 380 to 2000 centipoise.

With some water even the high viscosity no. 12 binder of 70,000 centipoise can be used in low percentages of about 2 per cent for adequate bonding of this sand. The viscosity range of 380 to 2000 appears an overall best for a variety of sands such as the five considered in Table 9. Other properties of the silicate must be taken into consideration, however, and are described in more detail in a later section.

Figures 7a and 7b are an attempt to correlate graphically the minimum critical percentage of a sodium silicate, such as the no. 1 silicate, required by

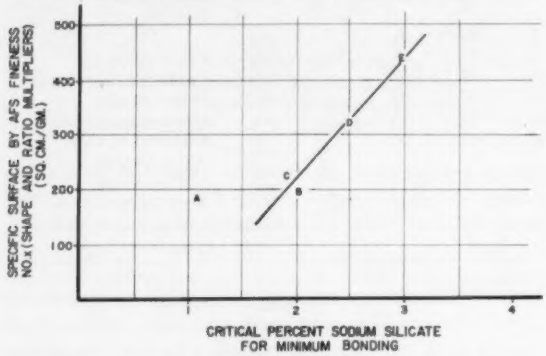


Fig. 7a — Sands *B, C, D* and *E* show a general relationship between the (AFS number) × (shape and ratio multipliers) and the critical percentage requirement of sodium silicate no. 1 for minimum bonding. Sand *A* does not satisfy this correlation.

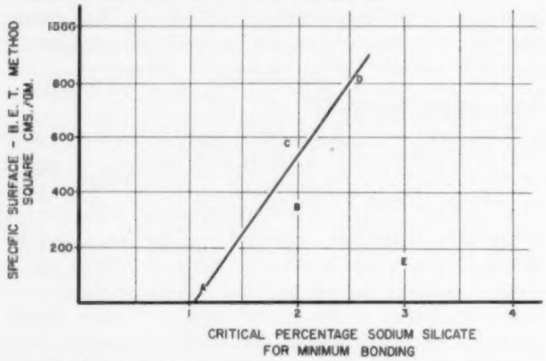


Fig. 7b — Sands *A, B, C* and *D* show a general relationship between specific surface by the B.E.T. method and the critical percentage requirement of sodium silicate no. 1 for minimum bonding. Sand *E* does not satisfy this correlation.

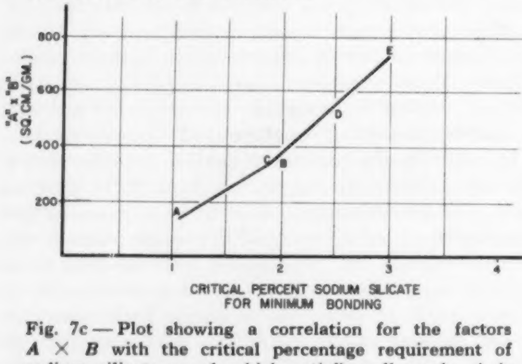


Fig. 7c — Plot showing a correlation for the factors *A* × *B* with the critical percentage requirement of sodium silicate no. 1 which satisfies all sands. *A* is (AFS no.) (est. surface shape factor) (ratio multiplier). *B* is (ratio representing specific volume differences).[4]

the five sands with their specific surfaces calculated by the AFS number times its shape and ratio multipliers, as well as by the B.E.T. method. As such, if correlation could be devised, initial silicate formulations could be predicted within a close range with a minimum of experimental work.

There is a fairly good general relationship for four of the five sands in each case—sand *A* being out when using the AFS fineness times the multiplier method, and sand *E* being particularly out of correlation with the B.E.T. method. By bringing another parameter into this, that of specific volume, we have developed a correlation shown in Fig. 7c by which all five sands correlate with this minimum percentage of sodium silicate for critical bonding. Variations in specific volume, a figure representing volume per unit weight, were determined with the test cylinders. The same weight of 185 grams gave variations in height of cylinder due to differences in sand as follows:

Sand Sample	Height Variations, in.
A	1.89
B	2.06
C	2.00
D	2.08
E	2.15

Specific Volume Comparison

The lowest common denominator of these height differences is a ratio comparison of their specific volume differences. This number, taken to the fourth power called *B*, is included with the other data in Table 9. Figure 7c shows the relationship of this number times the AFS number with its multipliers designated as *A*, plotted against the critical per cent sodium silicate for minimum bonding. There is a surprisingly good correlation which may be used as a guide for predicting this minimum bond requirement for any sand selected. There is no mathematical explanation for taking this ratio of specific volumes to the fourth power.

Hypothetically, we can consider those sands with high specific volume (indicating greater void content) as having a reduced number of contacts for structural bonding within a given volume. Thus, greater percentages of sodium silicate per unit weight would be required to give structural strength. As pointed out previously, however, it is better to fill these voids with fine grain sand such as the coarse silica flour which are large enough to act as structural building blocks contributing a considerable increase in number of bonding points.

Any one of these numerical parameters evaluates some characteristics of the sand considered, each contributing to the approach which may be used in formulating optimum use of sodium silicate and additives related to the molten metal poured against the mold surface. Practical results of these studies are presented in a later section. It is noted that each sand requires differences in formulation to obtain optimum properties in the cores and molds produced. Promiscuous use of proprietary formulas, expected to give equal performance on any sand chosen, seems unreasonable considering the results of these studies.

Proper cooperation between the formulator and the

foundry technologist related to the sand used, metal poured, size of castings and end use requirements should give optimum performance provided the formulator is aware of the changes necessary between one sand and another. The formulator has equipment for proper blending of all ingredients, saving the foundry the problem of obtaining a homogeneous mix at the time of make-up with the sand.

The attempt to numerically describe the characteristic difference in sands has been valuable from a practical use interpretation, but does not provide the establishment of theoretical concepts which can be used as a guide to predict the optimum sand for the CO_2 process. Reference papers[9,10] provide an excellent background for this type of thinking, but point out the limitations of the mathematical approach related to actual sand performance in foundry usage. Perhaps the data included here will contribute to later studies of a more mathematical effort.

THE SODIUM SILICATE BINDERS

Table 10 is a compilation of published properties of the 12 sodium silicate binders under in these studies. The no. 1 binder has been used predominantly in the study of other variables related to this CO_2 process. Comparatively, binders of this description show the best overall results and have been recommended with all the sands under consideration. Numerous references have presented technical, theoretical descriptions of the various silicates produced commercially.[16,18,19,21,29] Total solids content, viscosity and density difference given in Baumé are all easily understood properties which relate to flowability and actual dried binder qualities. The less understood variables are the ratio of soda to silica and the effect of water quantity in the chemical reaction with carbon dioxide to form carbonic acid, sodium hydrogen carbonate and the binder ingredient silica gel. These affect the rate of reaction with the carbon dioxide, the type of gel formation, the subsequent resistance to moisture pickup and final binder strength.

Silica to Soda Ratio

The silica to soda ratio, as well as the water content determined by the total solids, is of particular importance in determining the character of the final silicate adhesive bond. A strong, dry, brittle adhesive bond results where the silica content is the greatest and the soda is in lower percentages. As the soda (alkaline) percentage increases, there is a tendency to retain additional moisture in the system resulting in a more flexible film adhesive.

Gassing

The extent of CO_2 gassing can also vary the final properties of the silicate bond. The gassing mechanism consists in the formation of carbonate ions in the water system which form hydrated sodium bicarbonate in various complexes depending upon the amount of CO_2 injected, the water content and the temperature of the system. In addition to the water held chemically by the sodium carbonate, the hydrogen ions lower the pH causing the formation of silica gel which takes up water.

The greatest contribution of strength is through the residual sodium silicate which has been dried out by the removal of water in hydrating the sodium carbonate and in forming the silica gel. As the silica gel and hyrated sodium carbonate lose their water in storage, they lose strength, but they do contribute to the initial strength established by the gassing of CO_2.

Water Content Control

High water contents, together with continued gassing, finally deplete the sodium silicate as it is hydrated to silica gel and the hydrated sodium carbonate. It is important, then, to control the water content carefully and/or control the gassing time. If cores or molds are used immediately, this reduction in strength due to drying out of the silica gel and hydrated sodium carbonate is of less importance since this occurs generally in storage.

High relative humidity contributing continued moisture prevents the drying out of the sodium silicate to form the adhesive bond, and usually slows down the whole reaction as the highly viscous silica gel prevents permeation of the CO_2 gas through the sand sodium silicate system. Since there is strength contributed by the silica gel and the hydrated sodium carbonate, if the system is not dried out but retains some moisture there can be a final strength contribution by all three components. This results in a flexible system which is not completely dehydrated.

A moisture tempering of the bond, then, provides flexibility and toughness. Additives such as sugar assure the presence of moisture, and also provide a favorable dilution and flowability of the silicates during mixing. This property of low viscosity flow provides a thin adhesive layer, uniformly distributed over the sand grains and the coarse silica flour. The greater the thickness of this bond, the more chance for breakdown in the adhesive layer.

Sugar Addition

The control of water content for retaining such a flexible system is more difficult where ambient conditions vary from low humidities to high relative humidities. The rate of change and character of the hydrated components (silica gel and sodium bicarbonate) can be greatly improved by the addition of sugar, either in granular form or as a liquid syrup. This hydrophilic additive stabilizes the gel structure contributing strength and preventing rapid CO_2 gassing effects as well as rapid removal of moisture in dry conditions. There are many hypotheses concerning gel structures.

Some believe the structure predominately amorphous, and others believe them composed of myriads of fine needle-like crystals which vary in flexibility and elasticity. In any case, the sugar contributes a flexible toughness to the binder system which allows the use of lower percentages of the less flexible inorganic sodium silicate ingredient.

Experimental tests have shown comparatively poor results for invert sugar and foundry *A* syrup. Table sugar, uniformly distributed into the mix together with the sodium silicate and other additives, gave good results.

Any gel system can be deleteriously affected by

TABLE 5 — SOME FORMULATION STUDIES WITH CYLINDER CORE SPECIMEN USING SUB-ANGULAR HIGH DENSITY AFS 81, CODE C

Exp. No.	Silicate Binder Used, No.	Binder, %	Additives, % Sugar	Additives, % Water	Additives, % Iron Oxide	Additives, % Silica Flour	Compressive Strength, psi Before Heat	Compressive Strength, psi After Heat	Dietert Surf. Hardness Before Heat	Dietert Surf. Hardness After Heat	Flowability (Dietert)	Relative Humidity, %	Comments
239	1	2.0					125	108	56	58	80	58	Poor collapsibility
240	1	2.4					206	234	64	68	84	58	Poor collapsibility
243	1	2.7				4.0	100	35	51	58	81	58	120 mesh silica flour
244	1	2.7				4.0	95	80	55	45	82	58	90 mesh silica flour
245	1	2.7				4.0	100	100	59	46	82	58	120 mesh silica flour
246	1	2.7				4.0	135	100	64	62	85	58	200 mesh silica flour
247	1	2.7	2.0	0.5		4.0	156	137	78	72	82	58	Stand 5 hours
248	1	2.4	2.0	0.5		4.0	473	20	81	59	79	40	Stand 29 days, acceptable formulation
249	1	2.4	2.0	0.5	2.0	4.0	250	0	72	0	83	40	Stand 29 days, acceptable formulation
254	1	2.0	2.0	0.5		4.0	104	0	72	0	80	40	Stand 23 days, acceptable formulation
259	1	1.5										77	Not workable
260	1	1.7					48	23	53	43		56	
261	1	2.0				4.0	20	45	59	37		56	(Low strengths)
242	8	2.7									78	58	Too soft, no strength

changes in pH or the introduction of incompatible electrolytes. The use of additives with such an adhesive system is quite critical and accounts for the varied results with clays,[30] pelleted pitch, aluminum oxide, etc. With certain controlled formulations these may prove useful, but experience indicates that it would require considerable experimental effort to determine such optimum compositions.

Relative Humidity and Moisture Content

Minimum quantites of properly distributed bonding materials are considered an advantage. We are still faced with the problem, however, of almost complete breakdown of the sodium silicate bond under high relative humidity conditions. The absorption and adsorption of water into the system reduces the cohesive strength of the bond to almost nothing. We are faced with a favorable inclusion of some moisture and a considerably unfavorable result from excess moisture as absorbed by the humectant sugar-silica system.

Tables 1 to 7 show a convincing number of formulations containing from 1.8 to 2.5 per cent sodium silicate providing all the qualities of best CO_2 molding, provided the relative humidity is kept below approximately 70 per cent. A real effort has been made to obviate this problem of relative humidity. Favorable resistance to high humidity has been obtained by removing the sugar, but with the immediate return to the problem of poor collapsibility, reduced resistance to surface rubbing breakdown and poor properties of flow ramability.

Some systems have been found (Table 8) which are partially resistant to high humidities, the best being a surface spray with a silicone solvent system. Other data in this table show the possibilities for air-drying and the questionable use of calcium hydroxide. This material causes a rapid reaction which would be difficult to control. Many other materials were experimentally tried as additives with no benefit. Suppliers of sodium silicate suggest no possible method for alleviating this degradation with high humidity.

Continuous storage in high humidity can do nothing but degrade the surface hardness of a core or mold and eventually cause crumbling of the structure itself. It has been found, however, that the system is reversible to moisture, that is, the strength can be regained under dry conditions accelerated with a convection of dry air.

Compressive Strength and Surface Hardness Changes With Relative Humidity

Figure 8 is a bar chart showing changes in compressive strength and surface hardness with relative humidity. Two forms of sodium silicate have been considered in this evaluation of sensitivity to relative humidity. References[18,27,29] point out that silicates having high silica to soda ratios are inherently more resistant to high moisture conditions. Number 8 binder has a high ratio of 3.22 to 1 as compared to the 2-1 ratio of no. 1 binder selected for its overall good properties. The no. 8 binder also has a much lower solids content and a viscosity of 70 centipoise compared with 380 for the no. 1 binder of 2 to 1 ratio.

The experimental results plotted in the bar chart (Fig. 8) show a considerable difference between compressive strength and surface hardness for the binder. Relative humidities above 60 per cent reduced the compressive strength in every case. Although the no. 8 binder at the lower humidities gives less than half the strength of the 2 to 1 ratio silica to soda when used with the round grain *A* sand, the strength is reduced almost to an unusable condition when used with *D* sand. In surface hardness, however, the results are reversed at the higher 88 per cent relative humidity.

Compressive strength and surface hardness data evidently do not correlate with each other, but must be related to quantity of water present and the properties of the sand used. There are many other data in the experimental studies which further establish that the surface hardness can be enhanced with the addition of some moisture. Continued exposure to

TABLE 6 — COMPARATIVE EVALUATION OF VARIOUS SODIUM SILICATE TYPES WITH CYLINDER CORE SPECIMEN

Exp. No.	Sand Used	Silicate Binder, No.	Binder, %	Additives, %				Compressive Strength, psi		Dietert Surf. Hardness		Flow-ability Dietert	Rel. Hum., %	Comments
				Sugar	Water	Iron Oxide	Silica Flour	Before Heat	After Heat	Before Heat	After Heat			
104	A	1	1.5					279	132	75	72		Below 60	Smooth surface
122D	A	1	1.8	2.0	0.5	2.0		487	0	84	0		52	
167	A	1	2.5	2.0	0.5	2.0	4.0	628	60	95	72		42	Excellent
167	A	1	2.5	2.0	0.5	2.0	4.0	100	185	43	74		88	
239	C	1	2.0					125	108	56	58	80	58	
249	C	1	2.4	2.0	0.5	2.0	4.0	250	0	72	0	83	40	Stand 29 days
259	C	1	1.5										77	Not workable
272	E	1	2.5					50	0	66	0		41/55	
306	E	1	2.5	2.0	0.5	2.0	4.0	250	56	70	0		54	Usable for operation
274	E	1	3.5					196	150	85	70		41/55	Hard to handle
A2A	D	1	3.0					500	250	80	68		Room	Poor collapsibility
174	D	1	3.0	2.0	0.5			500	1	77	45		56	
174	D	1	3.0	2.0	0.5			2	2	0	57		88	
204	B	1	2.5					77	15	56	57		Normal	Good surface
204	B	1	2.5					5	20	0	63		88	
252	B	1	2.5	2.0	0.5	2.0	4.0	400	0	80	0		52	
345	D	3	3.0	1.5	0.3	2.0	*0.2	93	0	50	0		55	Gassed 10 S at 35 psi
335	B	3	3.0	2.0	0.5	2.0	4.0	180	0	56	0		50	Gassed 10 S at 35 psi
285	A	3	1.5					55	0	0	0	88	51-34	Very poor surface Gassed 10 S at 35 psi
311	A	3	1.8	2.0	0.5	2.0	4.0	245	0	60	0	82	48-55	Gassed 10 S at 35 psi
344	A	3	1.8					52	0	47	0	87	58	Fair surface
336	A	3	2.4	2.0	0.5	2.0	4.0	563	0	75	0		55	Gassed 10 S at 35 psi
296	C	4	2.8					66	0	39	0		45-39	Gassed 10 S at 35 psi
318	C	4	3.0	2.0	0.5	2.0	4.0	120	0	60	0	73	55	Gassed 10 S at 35 psi
286	A	4	1.5					6	0	0	0	87	51-34	Gassed 10 S at 35 psi Very poor surface
312	A	4	1.8	2.0	0.5	2.0	4.0	520	0	75	0	78	55	Gassed 10 S at 35 psi
345	A	4	1.8					12	0	23	0	85	50	Poor surface, 10 S gassing
291	B	4	2.4					55	11	49	20	78	43	Gassed 10 S at 35 psi
315	B	4	2.4	2.0	0.5	2.0	4.0	55	0	52	0	83	55	Gassed 10 S at 35 psi
300	D	4	2.5										55	Too dry
320	D	4	3.2	2.0	0.5	2.0	4.0	250	0	71	0		55	Gassed 10 S at 35 psi
305	E	4	3.0					12	0	32	0		55	Gassed 10 S at 35 psi
279	A	9	2.0										55	Too dry
307	A	9	2.0	2.0	0.5	2.0	4.0	362	0	71	0	80	53	
233	A	9	2.5	2.0		2.0	4.0	2	0	25	0		80	Sticky, lumpy
233	A	9	2.5	2.0		2.0	4.0	2	0	0	0		88	
235	B	9	2.3											Poor results
301	E	9	3.5											Too dry
292	C	9	3.2					2.5	0	0	0	80	43-34	Very poor surface
316	C	9	3.7	2.0	0.5	2.0	4.0	55	0	65	0		55-68	
281	A	10	2.5					130	220	80	80	92	46	
308	A	10	2.0	2.0	0.5	2.0	4.0	480	35	81	23	81	56	
293	C	10	3.2					71	160	84	75	83	43	
317	C	10	3.2	2.0	0.5	2.0	4.0	440	130	82	58	73	68-55	
284	A	11	1.5										54	Not workable (lumps formed)
284A	A	11	1.5		0.3			2.5	0	27	0	83	43	
310	A	11	1.5	2.0	0.9	2.0	4.0	350	4	68	0	82	55	
283	A	12	1.5											Not workable, silicate did not go into mix
303	E	12	2.5		0.5			50	0	33	0		55	No comparison
280	A	5	1.8					38	14	27	5	76	44	Poor surface
343	A	5	1.8					38	132	60	65	87	55	10 S gassing, good surface, 48 hr, stand
295	C	5	2.8					48	50	71	63	84	44	10 S gassing, fair surface, 72 hr, stand
304	E	5	3.0					19	0	50	0	84	44	10 S gassing
299	D	5	3.2					19	0	68	0	81	44	10 S gassing
288	B	5	2.6					18	0	32	0	75	44	10 S gassing
157	A	6	2.5	2.0	0.5			500	0	80	40		45	
157	A	6	2.5	2.0	0.5								88	No good
282	A	7	1.5					10	0	8	0	88	46	Surface poor, dries rapidly
309	A	7	1.8	2.0	0.5	2.0	4.0	160	0	81	23	81	55	
302	E	7	3.0					6.3	0	30	0		55	
297	D	7	2.5					6	0	25	0	82	42	
319	D	7	2.8	2.0	0.5	2.0	4.0	56	0	58	0	78	55	
289	B	7	2.4					20	0	35	0	89	35	
314	B	7	2.7	2.0	0.5	2.0	4.0	120	0	59	0	78	55	
164	A	8	2.5			2.0							45	Dries too rapidly

(continued on next page)

TABLE 6 — CONTINUED

Exp. No.	Sand Used	Silicate Binder, No.	%	Additives, % Sugar	Water	Iron Oxide	Silica Flour	Compressive Strength, psi Before Heat	After Heat	Dietert Surf. Hardness Before Heat	After Heat	Flow-ability Dietert	Rel. Hum., %	Comments
165	A	8	2.5	2.0		2.0	4.0	628 +	0	90	0		47	
165	A	8	2.5	2.0		2.0	4.0	73	0	58	0		88	
158	A	8	2.5	2.0	0.5	2.0		180		93			45	
158	A	8	2.5	2.0	0.5	2.0		10		50			88	
159	A	8	2.5	2.0	0.5		5.0	275	3	93	45		50	
159	A	8	2.5	2.0	0.5		5.0	30	3	69	45		88	
242	C	8	2.7									78	58	Too soft, no strength
170	E	8	4.5	2.0				163		94			Room	Difficult to remove
170	E	8	4.5	2.0				80		80			88	from mold
276	E	8	3.0					*						Not workable
231	B	8	3.5	2.5			4.0	220	2	92	26		45	Dries out, but good surface
231	B	8	3.5	2.5			4.0	3	2	38	38		88	
287	B	8	3.2										46	Not workable
313	B	8	2.5	2.0	0.5	2.0	4.0	62	0	64	0	80	55	
160	D	8	4.0	2.0	0.5			22	0	93	0		50	
160	D	8	4.0	2.0	0.5			2	0	61	0		88	
176	D	8	3.5	2.0				158	0	87	0		50	Good surface
290	B	12	1.8											Not workable, silicate does not mix in
294	C	12	2.2											Silicate does not mix in
177	D	12	2.0	2.0	0.5			350	0	79	0		60	Excellent surface
177	D	12	2.0	2.0	0.5			2	0	7	0		88	
178	D	12	2.0	2.0										Too dry
298	D	12	2.0										57	Not workable

*Cresol-phenolic organic derivative

high humidity, however, will finally result in the breakdown of the surface as well as the internal structure.

A 10-in. 90 deg. elbow core formed of formulation 165 (Table 3) was placed in an open structure in the rain for more than 24 hr, with reductions of surface hardness from 65 to 60 resulting in a final core reasonably strong enough for a metal pour. This formulation using the no. 8 silicate under normal conditions of humidity, however, is not equivalent in overall properties with other selected formulations using the 2 to 1 ratio silicate, and should be used only under high humidity conditions to give fair casting results. A solvent carried silicone spray, applied over the surface on the CO_2 molded core, further reduced the penetration of moisture (Table 7, experiments 135, 145).

A convincing argument is given in literature[18] with supporting data, to keep at a minimum the initial strength contributed by the CO_2 gassing. The strength attributed to the CO_2 silica reaction is in the form of a silica gel. Subsequent drying removes the gel formation resulting in a complete breakdown of the strength initially contributed by the gel. On

TABLE 7 — COMPILATION OF SPECIAL STUDIES

Exp. No.	Sand Used	Silicate Binder, No.	Binder, %	Additives, % Sugar	Water	Iron Oxide	Silica Flour	Other	Compressive Strength, psi Before Heat	After Heat	Dietert Surf. Hardness Before Heat	After Heat	Rel. Hum., %	Comments
129	A	1	1.8	2.0	0.5	2.0			600	0	90	0	30	Gassed with CO_2 20 S at 35 psi then 30 S at 35 psi with N_2
129	A	1	1.8	2.0	0.5	2.0			0	0	0	0	88	
118F	A	1	1.8	1.5					585	209	62	40	28	Gassed with compressed
118F	A	1	1.8	1.5					189	186	70	52	76	air 20 S at 35 psi
118G	A	1	1.8	1.5					566	5	52	47	29	Gassed CO_2 and com-
118G	A	1	1.8	1.5					200	0	70	60	76	pressed air 20 S at 35 psi
121A	A	1	1.8	1.5	0.375				322	10	68	33	31	Gassed with compressed
121A	A	1	1.8	1.5	0.375				5	110	10	58	76	air 20 S at 35 psi
121B	A	1	1.8	1.5	0.375				478	6	73	42	31	Gassed CO_2 and com-
121B	A	1	1.8	1.5	0.375				110	8	40	48	76	pressed air 20 S at 35 psi
135	A	1	1.8	2.0		2.0			504	0	75	0	29	Sprayed with a solvent
135	A	1	1.8	2.0		2.0			38	0	55	0	88	carried silicone spray
123	A	1	1.5	2.0		2.0			0	0	0	0	76	Sprayed with a water
123	A	1	1.5	2.0		2.0			0	0	0	0	88	containing silicone spray
145	A	1	1.8	2.0	0.5				325	16	80	60	60	Cores dipped in 12%
145	A	1	1.8	2.0	0.5				200	37	48	60	88	hydrous magnesium silicate methanol solution
146	Noncode round grain	1	1.8	2.0	0.5				465	6	98	82	54	Dipped in aluminum
146	Noncode round grain	1	1.8	2.0	0.5				0	5	2	90	88	hydrogen phosphate

(continued on next page)

TABLE 7 — CONTINUED

Exp. No.	Sand Used	Silicate Binder, No.	Binder, %	Additives, % Sugar	Water	Iron Oxide	Silica Flour	Other	Compressive Strength, psi Before Heat	After Heat	Dietert Surf. Hardness Before Heat	After Heat	Rel. Hum., %	Comments
155	Noncode round grain	8 and Noncode binders	2.0	2.0	0.5				563	0	79	22	45	
155	Noncode round grain	8 and Noncode binders	2.0	2.0	0.5				2	0	7	40	88	
201	A	Noncode binders	3.0	2.0		2.0	4.0		154		85		Normal	Very dry, fair surface
201	A	Noncode binders	3.0	2.0	0.5	2.0	4.0		2		0		88	
202	D	Noncode binders	3.5	2.0	0.5	2.0			179		85		Normal	Dries fast
202	D	Noncode binders	3.5	2.0	0.5	2.0			2		8			
126	A	1	1.8	2.0	0.5	2.0		0.25[a]	550	0	80	42	Room	
126	A	1	1.8	2.0	0.5	2.0		0.25[a]	8	0	30	40	76	
127	A	1	1.8	2.0	0.5	2.0		1.0[b]						No strength
128	A	1	1.8			2.0		1.0[b]						No strength
141	A	1	1.8	2.0	0.5	2.0		2.0[c]						Too soft
168	A	1	1.8	2.0	0.5			6.0[d]	212		80		Room	Heat given off
168	A	1	1.8	2.0	0.5				108				88	
133	A	1	1.8	2.0	0.5			Fire Clay 2.0	465	0			55	
140	A	1	1.8		0.5	2.0		2.0[e]						Too weak
153	Noncode round grain	1	1.8	2.0	0.5			4.0[f]						Initial gas form an impervious coating stopping effectiveness of gas on center core
154	Noncode round grain	1	1.8	2.0	0.5			2.0[f]						No strength
219	Noncode round grain	8	2.5	2.0				1.0[g]						Too dry
202	Noncode round grain	8	2.5	2.0				0.25[g]						Sticky. Not workable
272	Noncode round grain	1	1.5	2.0				0.125[g]	2	0	0	0	45	All ingredients except zinc stearate mixed 4 min. Zinc stearate added and mixed with others for 1 min. Total 5 min.
272	Noncode round grain	1	1.5	2.0				0.125[g]	1	0	0	0	88	
212	Noncode round grain	8	2.5	2.0			4.0	6.0[h]	250	0	90	0	Normal	Dries fast, flowability 78
212	Noncode round grain	8	2.5	2.0			4.0	6.0[h]	4	0	30	0	88	
213	Noncode round grain	8	2.5	2.0			4.0	3.0[h]	170	0	92	0	45	Flowability 81
213	Noncode round grain	8	2.5	2.0			4.0	3.0[h]	27	0	38	0	88	
214	Noncode round grain	8	3.0	2.0			4.0	4.0[h]	2.5	0	30		88	No humidity resistance

[a] A water containing silicone spray
[b] Aluminum hydrogen phosphate
[c] Liquid urea resin
[d] $Ca(OH)_2$
[e] Hydrous magnesium silicate
[f] Portland Cement ($CaCl_2$—10%)
[g] Zinc Stearate
[h] ZnO

the other hand, the remaining silicate binder which has not been reacted by the gas will contribute proportionally considerably more strength as the water is removed leaving the silicate as an adhesive binding material.

Excessive water in the initial system enhances the rate of the CO_2 reaction giving initial high silica gel strengths but resulting in later decreased strengths as the system is dried out.

Water Quantities to Control

There are then, three quantities of water to consider and control carefully in the CO_2 molding process. This is assuming that the sand itself is dry:

1) The water is a part of the sodium silicate binder.
2) The water which is added with the sugar, syrup or as a controlled additive quantity in the initial mix.
3) The pickup of moisture in storage due to high relative humidities.

Proper choice of formula will obviate all these problems of water content provided the relative humidity during storage before usage is below 70 per cent. The gassing reaction to form the silicate gel becomes less sensitive to the water content with the favorable additives such as sugar and iron oxide. A desirable uniform coating of the sand grains during the mixing of formulation ingredients, or with a prepared composition, depends considerably upon viscosity of the binder material as well as the flowability of the sand during such a mixing action.

Controlled Gassing

A thin film of the silicate adhesives is most desirable. Excessive quantities of the binder only reduce the cohesive strength of the overall film. The strength of any mass is proportionately greater the smaller the quantity considered. Probability of structural breakdown gives credence to this hypothesis.

The previous discussion concerning water content

TABLE 8 — VARIATIONS IN GASSING AND ADDITIVES TO OBVIATE HUMIDITY PROBLEM

Exp. No.	Formula Change	Result	Effect on Collapsibility
168	Calcium hydroxide	Good	
118E, 121	Pre-drying in oven	Good	No effect
118F, 121A	Gassing with compressed dry air	Fair	No effect
118G, 121B	Gassing with combination of CO_2 and compressed air	Fair	No effect
135	A solvent carried silicone spray	Fair	No effect
145	Dipping in a hydrous magnesium silicate methanol mix	Fair	Some decrease
212, 213	Zinc oxide	Fair	
165, 166, 229	High silica to soda ratio silicates	Fair	Not favorable
122, 163	Iron oxide	Poor	Very good
129	Nitrogen replacing CO_2	Poor	No strength
129	Gassing with Nitrogen and CO_2	Poor	No effect
123	A water containing silicone spray	Poor	Not determined
124, 126	A water containing silicone compound mixed into formula	Poor	Not determined
127	Aluminum hydrogen phosphate addition	Poor	Incompatible
146	Dipping in an aluminum hydrogen phosphate	Poor	Decrease greatly
140	Addition of a hydrous magnesium silicate	Poor	No strength
201, 202	Liquid and solid silicate mixture	Poor	No effect
155	Mixed silicates	Poor	Not determined
161	Cresol-phenolic plastic powder	Poor	Decrease slightly
133	Fireclay	Poor	No effect
153	Calcium chloride	Poor	No strength
219, 220, 227	Zinc stearate	Poor	No effect
141	Liquid urea resin	Poor	No strength

of the silicate formulation indicated a need for controlled gassing. Laboratory studies have considered the variables of the gas pressure, gas composition and quantity and rate of gas usage, as controlled by venting and size of feed apertures. The laboratory gassing of test cylinder specimen was determined as 20 sec through a $\frac{5}{16}$-in. diameter exit at 35 lb gage pressure. A fine mesh corrugation support at the bottom of the cylinder during the gassing provided adequate venting.

Plant trials with muffle boards clamped as manifolds over wooden or metal core boxes gave best gassing performance when the boxes were well vented to allow a gas passage which will not exceed 10-in. laterally and 4 in. in diameter of flow (Fig. 9).

The structural strength initially developed with the CO_2 gas allows immediate handling of the mold or core. This is not the best bond which sodium silicate can contribute, however, since drying in storage will add considerably to the strength. Minimum CO_2 gassing to give adequate structural strength for normal core and mold handling is preferred. If the sand-silicate structure can be retained in place either by green strengths or adequate moderately high temperature resistant supports, convection drying or dielectric heating methods can be used to remove the moisture resulting in a strongly bonded silicate adhering structure requiring no CO_2 gas application.

In this case no gelling by CO_2 gas occurs, and there is no irreversible loss by drying of silicate bonding materials. This is one approach to semi-precision molding using heat methods similar to those used in phenolic shell molding.[26]

Figure 10 is a laboratory demonstration of one of

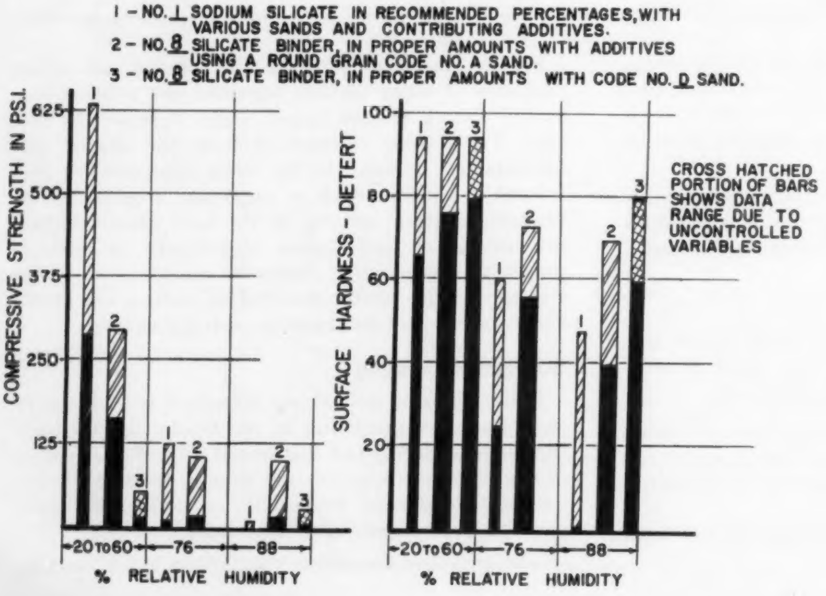


Fig. 8 — Relative humidity effect on strength and surface hardness.

Fig. 9 — Gassing production half cores using a manifold and vented box.

the many methods of gassing[20,34] in which a glass reinforced epoxy pattern of shell construction, vented adequately through the surface, can be gassed from the inside cavity out through a mold of shell thickness providing enough initial strength for pattern removal and subsequent curing in a dielectric oven. There are advantages for gassing with a vacuum chamber where short runs on varied sizes of cores and molds are produced. There are reductions of CO_2 gas requirements also purported. Experiments 129, 118F, 118G, 121A, 121B (Tables 7 and 8) show the favorable possibilities of using dry air, hot air, nitrogen gas or the dilution of CO_2 gas with dry air.

The controlled gassing of experimental cylinder specimens supported literature knowledge, and supplied information that each sodium silicate binder

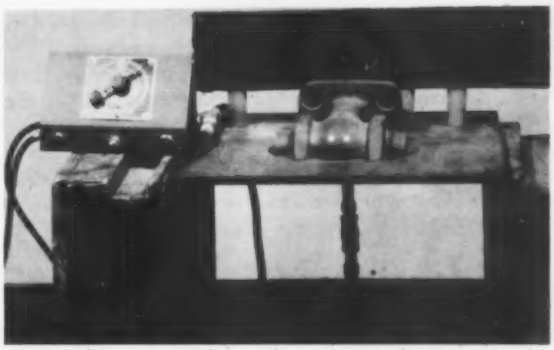


Fig. 10 — Laboratory demonstration of one of the methods of gassing in which a glass reinforced epoxy pattern of shell construction can be gassed from the inside cavity out through a mold of shell thickness.

composition related to difference of silica to soda ratio, water content and viscosity has its own optimum quantity of CO_2 for adequate initial strength as a gel form adhesive. The 51 degree Baumé binder no. 1, for instance, was gassed 20 sec at a 35 lb pressure, compared with 5 to 10 sec for a 52 degree Baumé silicate containing more silica due to a 2.4 to 1 ratio rather than a 2 to 1 ratio silica to soda content.

OTHER VARIABLES FOR CONSIDERATION

This designation should not be construed as minor. They are no less important than those previously considered. With the proper attention, however, they can easily be controlled within certain operating limitations. Let us consider:

Mixing Methods and Time

The order in which the ingredients of the formulations are added to the mixing unit, the action of the mixer and the time of the mixing can either be carefully controlled or given little attention. We know that CO_2 from the air and the action of drying will pre-set the silicate adhesive bond. If this occurs before the core or mold is formed, this amount of strength-giving sodium silicate is lost, and will even

TABLE 9 — NUMERICAL PARAMETERS COMPARING FIVE REPRESENTATIVE SANDS WITH THE MINIMUM CRITICAL PER CENT BINDER 1 REQUIREMENT

		Rounded Grain Ottawa Wedron	Sub Angular AFS 70 New Jersey	Sub Angular High Density AFS 81 New Jersey	Cape Sand AFS 105	Fine Grain Sub Angular Dividing Creek
Code Number		A	B	C	D	E
Retained on screen	40	0.2	0.7	1.8	0.6	0.2
	50	4.4	7.4	17.3	1.4	1.8
	70	31.2	30.6	30.4	6.0	4.6
	100	41.2	42.4	22.6	30.6	11.2
	140	15.4	14.6	11.3	34.4	22.4
	200	5.6	3.0	8.0	19.2	25.6
	270	1.4	0.8	4.4	4.6	14.0
	325	0.6				
	PAN		0.5	3.7	3.2	20.3
AFS Fineness No.		73.92	70 ±5	81 ±5	105	158
Est. Surface shape factor		1.35	1.50	1.50	1.65	1.50
Specific surface by using ratio multiplier (1.82), called *A*, sq cm/gm		182	191	221.1	315	432
Specific surface B.E.T. Method, sq cm/gm		50	358	584	810	152
4th power of specific vol. ratios, called *B*		1.0	1.43	1.25	1.47	1.69
Multiple of *A* x *B*		182	273	276	464	730
Minimum Critical % Binder 1 Requirement		1.1	2.0	1.9	2.5	3.0

interfere with the proper bonding when the sand is rammed into position.

The mixing should be stopped immediately then when the sand grains are uniformly coated with the proper distribution of the formulation ingredients. Proprietary mixes have been pre-blended and have uniform ingredient distribution. Other additives such as silica flour and iron oxide can be pre-dry mixed before adding the sodium silicate, sugar and water compositions. A cresol-phenolic organic powder added in the small amount of 1 gram/lb of sand improves the flowability of those mixes which ram with difficulty.

Mixers operated from 1½ to 5 min depending on the difficulties of the mix, give adequate results in the laboratory. Mixers which throw the sand causing aerated drying should be avoided. The literature,[27] as well as experimental results, favor a simultaneous addition of sodium silicate, sugar and water rather than mixing them each separately into the sand.

Storage of Mix and Cores

The storage life of a sodium silicate sand mix depends considerably upon how it is kept uniform in water content. Tight metal containers covered with wet burlap bags sealed off from the CO_2 of the atmosphere can be kept for at least a day.

The storage life of a formed and gassed core or mold, however is almost indefinite, provided the relative humidity is not excessive for a time which would cause penetration and collapse of the bond structure. Even if they become weakened by high relative humidity, if they hold their shape, cores and molds will still be usable when adequately dried out before handling.

The Flowability of the Mix

The flowability of the sand binder mixture depends considerably upon the composition such as sand, type of silicate and additives used. The choice of recommended formulations given later has taken into account the valuable aspect of flowability. Structural strength and surface uniformity of the formed part depends upon optimum packing and uniform density of all parts of the structure. Flowability, as it concerns ramability and adaptability to best blowing or vibrating, makes these characteristics possible.

There is no reason why any of the recommended formulations should not be used for blowing, ramming or vibrating equal with green sand and urea bonded formulations. Plant runs have proven these formulations quite adaptable. Variations from these general types of formulas such as using additional binder, varying the type of silicate used or changing the sand without changing the sodium silicate content, may result in problems in ramming or blowing to form optimum core structure.

Adding water, or changing the silicate to improve the flowability of the mix without proper consideration of other properties, may result in poorly bonded cores or cores with poor collapsibility. Choice of sand to give adequate ramability is also important, and should not be determined without careful study. A laboratory attempt to compose a sand of perfect distribution for packing resulted in one with poor flowability. Sand distribution must consider flow and permeability as well as structural characteristics.

Temperature

Practically all chemical reactions are sensitive in some degree to temperature. The bonding with sodium silicate is no exception. However, ordinary ambient conditions are usually considered in the operationable range. Since the viscosity of the silicate decreases with temperature and the gelling action is accelerated with temperature, these would be markedly reduced if the sand or silicate were used immediately from a low temperature storage. Re-used sand, if allowed to remain hot in the mix, would cause accelerated drying resulting in a poorly bonded structure due to pre-dried silicate on the sand previous to mold forming.

RECOMMENDED FORMULATIONS

These selected formulations are based upon optimum properties determined by experimental studies taken from the various tables of results. Each sand is presented separately. Figures 11, 12 and 13 are examples of favorable results in the actual use of these formulations compared with standard core results.

Code D Sand

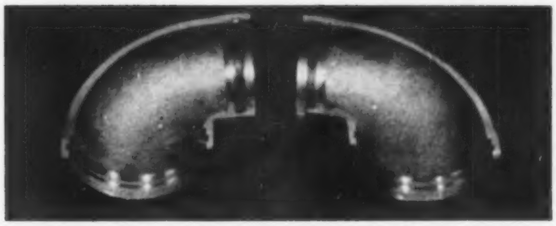
This sand is easily available in New England but not recommended as a selected sand for CO_2 molded cores. The high surface area with variable quantities of contaminants, such as mica, require higher percentages of bonding mixtures. The addition of small amounts of selected organic additives to this sand, are found to contribute:

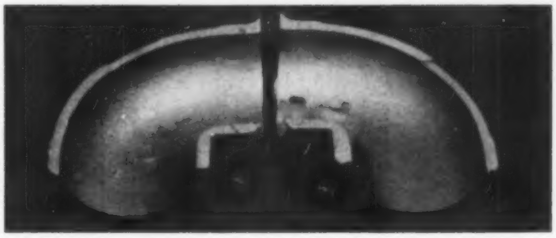
a) Flowability (ramming qualities) providing uniform density of the core or mold structure.
b) Production of just enough gas at the metal mold interface to prevent penetration and veining which seem prevalent when pouring the copper metals against this sand.

The formulas given in Table 11 have shown quite acceptable properties in the laboratory studies, and those designated have shown good performance in the plant operations.

Numbers 1 and 2 binders are 2 to 1 silica to soda ratio sodium silicates, 51 degree Baumé of about 380 centipoise viscosity. Number 8 binder is a 3.22 to 1 silica to soda ratio sodium silicate, 38 degree Baumé of about 60 centipoise viscosity. Binders nos. 1 and 2 have been found superior in their effectiveness in the CO_2 bonding process, but no. 8 binder gives some resistance and better performance in conditions of high humidity. Numbers 3, 4 and 5 binders are the type sodium silicates predominately used in the foundry industry. The silica to soda ratio is 2.4 to 1, 52 degree Baumé of about 1700 centipoise viscosity and 47 per cent total solids.

The laboratory evaluation comparisons show acceptable results, but in many ways the resulting cores and molds are inferior to the preferred 1 and 2 binders. The important advantage of these 3, 4 and 5 silicate binders is the shorter time of gassing required, which allows increased production with shorter gas



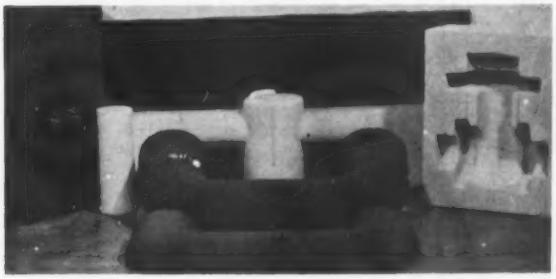


Figs. 11-13 — Examples of favorable results in the actual use of the recommended formulations compared with standard core results.

Fig. 11 — (left) — Sectioned casting, urea cored.

Fig. 12 — (lower left) — Sectioned casting, CO_2 cored.

Fig. 13 — (below) — Finished half cores and molds, including bonded half cores.



application cycles. Formulation 320 is included where this increased production rate seems important. Numbers 1 and 2 binders could be used in this same formulation with best results.

These formulations give adequate collapsibility over the higher temperature range required for brass (Figure 14 shows the results for formula 250 immersed in various furnace temperatures for 1 min and 5 min).

Code B Sand

Table 12 is a compilation of selected formulations using code *B* sand. The test data indicate formulas 230 and 252 as superior in all around requirements. Figure 14 is a collapsibility study of formulas 251, 207 and 252 using this sand, in which the cylinder specimen were immersed at various furnace temperatures for 1 min and 5 min. Code *C* sand is one which was recommended as possibly superior for the sodium silicate-CO_2 process. Data do not substantiate this possibility, and these recommended formulations do not include this sand competitively.

Code A Sand

This round grain sand is of highest silica composition and seems particularly suited for the sodium silicate-CO_2 molding process. Low percentages of binder are adequate, and a wide variety of formulations give excellent results (Table 13). Where the simple formulas such as 118 may present problems of hot expansion deformations (such as scabbing, and hot casting cracks), formulas such as 167 will correct this deficiency and reduce problems of penetration.

Code E Sand

Code *E* sand is included (Table 14) because it provides smooth surface cores and molds with lowest density packing. This combination reduces the possibility of providing adequate strength without sacrificing collapsibility. However, this sand with the silicate adhesive-type binder probably is superior to others where hot expansion problems are serious, causing mold wall fractures. The subangular, multiple screen properties of this sand allow movement with metal shrinkage where a coarser closely packed

TABLE 10 — PHYSICAL PROPERTIES OF SODIUM SILICATE BINDERS CONSIDERED IN THESE STUDIES

Silicate Binder Code Number	1	2	3	4	5	6	7	8	9	10	11	12
Ratio $Na_2O:SiO_2$	1:2	1:2	1:2.4	1:2.38	1:2.4	1:2.87	1:2.54	1:3.22	1:3.75	1:1.8	1:1.6	1:2.0
Na_2O, %	15	14.7	13.7	13.9	13.8	11.14	12.85	8.2	6.75	13.4	19.5	18.0
SiO_2, %	30	29.4	32.9	33.1	33.1	32.04	32.6	26.4	25.3	24.1	31.2	36.0
Total solids, %	45	44.1	46.6	47.0	46.9	43.18	45.45	34.6	32.05	37.5	50.7	54.0
Baumé (degrees)	51	50.5	52	52.25	52	47.59	50.5	38	35	44.6	58.5	59.3
Viscosity (centipoise)	380, est.	350	1600, est.	1700, est.	1700, est.		1120	60	220	60	7000	70000

Minimum Critical Percentage Sodium Silicate Binder								Best With No Water Addition					Additional Maximum % Can Add Using Proper Additives
Sand A	1.1	1.6	1.6	1.7	1.5	1.4	1.7	2.1	*1.5	1.6	N.W.	*N.W.	1.4
B	2.0	2.2	2.4	2.4	2.6		2.6	3.2	*N.G.			*N.W.	1.2
C	1.9			2.8	2.5				*N.G.	2.5		*N.W.	0.6
D	2.5		3.0	2.8	3.4		2.8	3.0					'0.8
E	3.0			3.3	3.3		3.2	3.8	*N.G.			*2.8	0.6

Critical percentage figures for binder 1 are based on considerable data. The critical percentages for the other binders dependent upon the sand used are based only on minimum experimental results—taken from Table 6.
*Reauires water addition, N.W.—not workable

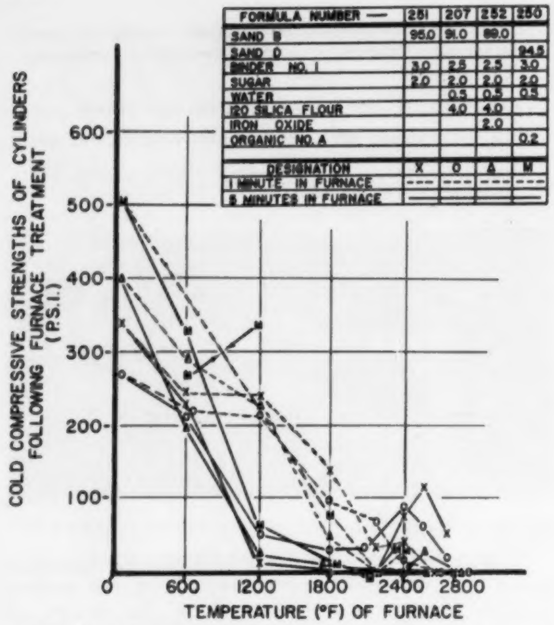


Fig. 14 — Furnace temperature effect on representative solium silicate CO_2 formulations.

round grain sand will require additions of organic cushioning materials such as wood flour[11] to extend the hot deformation properties of the mold structure.

The silicate bonded cores of this sand can be assisted in structural strength considerably with the addition of the coarser silica flours. Since the work with this sand was limited to a few trials, the optimum quantity addition is only estimated (Table 14).

LABORATORY EVALUATION METHOD

The initial series of cores made in the laboratory for metal casting in works production indicated the variable characteristics which seem important for controlling plant operations. The operating costs, quality of casting surfaces and dimensional precision are dependent upon the formulation selection and the conditions of mixing and gassing. To attain the optimum in all these aspects requires a knowledge of formulation and process variables. This knowledge was accumulated by laboratory and plant studies. The laboratory methods evolved by initial trial and error methods correlated with plant runs is described in the following paragraphs.

Procedure

Sand, sodium silicate, sugar and other additives are weighed out to the nearest 0.1 gram on laboratory balances. Mixes of 12½ lb in one laboratory mixer or 25 lb in a second mixer are prepared to a homogeneous consistency (Fig. 15). The dry ingredients were mixed first, followed quickly by a simultaneous addition of all liquid materials (sugar being initially dispersed in water if a water addition is included). Otherwise, the sugar is added with the sodium silicate.

The test cylinders are formed by placing 185 grams of the fresh mixtures into a polished metal cylinder of 2¼ in. inside diameter. The sand silicate mix is smoothed to a uniform thickness in the cylinder and placed in a press, as shown in Fig. 16. A solid metal cylinder piston with a self-aligning fixture attachment in the laboratory press is pressed into the cylinder against the sand to a 500 lb total pressure.

TABLE 11 — RECOMMENDED FORMULATIONS WITH CODE D SAND AND ADDITIVES

Lab. Exp. No.	See Table No.	Date of Plant Run	Silicate Binder Used, No.	Binder, %	Additives, % Sugar	Water	Iron Oxide	Silica Flour (90-140M)	Other
		12/27/57	1	3.0	2.0	0.33			
174	1	10/10/58 and	1 or 2	3.0	2.0	0.5			*0.2
250	1	10/14/58 also 6/24/58 and 6/4/58							
236	1		1 and 2	3.5	2.0				
320	6		3, 4 and 5	3.2	2.0	0.5	2.0	4.0	
176	1		8	3.5	2.0				
177			12	2.0	2.0	0.5			

*Cresol phenolic organic derivative.

TABLE 12 — RECOMMENDED FORMULATIONS WITH CODE B SAND AND ADDITIVES

Lab. Exp. No.	See Table No.	Date of Plant Run	Silicate Binder Used, No.	Binder, %	Additives, % Sugar	Water	Iron Oxide	Silica Flour (90-140m)
*251 and	2			3.0 to				
236	2		1	3.5	2.0			
324	2	Plant Production	2	3.0	2.0			
230 and	2							
207			1	2.3 to 2.5	2.0	0.5		4.0
252	2		1	2.5	2.0	0.5	2.0	4.0

*Compare with Exp. 324 with 3% no. 2 binder (Table 2); No. 236 gave better collapsibility.

TABLE 13 — RECOMMENDED FORMULATIONS WITH CODE A SAND AND ADDITIVES

Lab. Exp. No.	See Table No.	Date of Plant Run	Silicate Binder Used, No.	Binder, %	Additives, %				
					Sugar	Water	Iron Oxide	Silica Flour	Cresol Phenolic Organic Derivative
118	3	12/31/57	1	1.8	1.5 to 2.0	0.35			
122	3		1	1.8	2.0	0.5	2.0		
167	3		1	*2.2 to 2.5	2.0	0.5	2.0	4.0	
136	3	12/31/57	1	1.8	2.0	0.35			0.2
165	3		8	2.5	2.0		2.0	4.0	
157	3		6	2.5	2.0	0.5			
308	6		10	2.0	2.0	0.5	2.0	4.0	
336 and 312	6		5, 4, 3	*2.0 to 2.4	2.0	0.5	2.0	4.0	

*Percentage depends upon requirements of collapsibility.

TABLE 14 — RECOMMENDED FORMULATIONS WITH CODE E SAND AND ADDITIVES

Lab. Exp. No.	See Table No.	Date of Plant Run	Silicate Binder Used, No.	Binder, %	Additives, %			
					Sugar	Water	Iron Oxide	Silica Flour (90-140m)
349	4		1	1.8				
and				and				
306	4		1	2.5	2.0	0.5	2.0	4.0
*350	4		1	3.5	2.0	0.5	2.0	4.0
		Proposed Formula......	1	2.5 to 3.5	2.0	0.5	2.0	6 to 12

*Shows poor collapsibility; 2.4% is the limit for retaining acceptable collapsibility even with the additives.

This appears to equal uniform plant ramming, giving a compaction of sand similar to blown cores with density and permeability varying only according to the sand and silicate sugar formulation used. All cylinders of a given formulation, however, came out surprisingly of the same height indicating a uniformity of density by this controlled pressure method.

The cylinder assembly is removed from the press, tapped lightly with a rubber hammer and gassed with a standard plunger gassing unit for 20 sec at 35 lb pressure (Fig. 17). In some cases, the gassing time was changed depending upon the type of sodium silicate used as the bonding ingredient. Figure 18 is an example of such cores ready for test. Scratch hardness was made on each test series. Two to four readings were made before the muffle furnace heat immersion and after heat immersion (Figs. 19, 20). Figure 21 shows a cylinder being evaluated from compressive strength before heat application.

At least three cores from each series were place in the muffle furnace at a controlled high temperature. In most cases, this was at a temperature of 2200 F. The time of heat immersion was eventually standardized at 5 min (Table 16 gives a correlation comparing two, five, and 15 min in the furnace at 2200 F). Figure 22 is an example of such a furnace run.

The cylinders after heat (Fig. 23) will vary in strength and surface hardness according to the potential collapsibility of the formulation tested (Figs. 20 and 24).

Variations in storage time and conditions of relative humidity were recorded at the time of mixing and in storage. Controlled comparisons were made on cylinder cores kept in desiccators at different relative humidities (Fig. 25). Tables 15 and 16 are examples of data recorded during two experimental studies. The data recorded in Tables 1 through 8 are compiled from such sheets.

The flowability of some of the experimental mixes as recorded in the tables of results were determined with a flowability indicator which was used as an

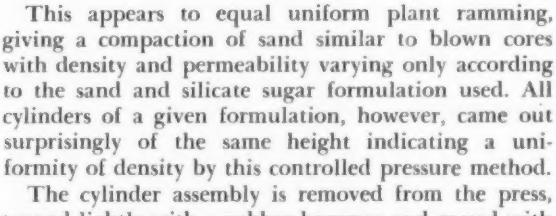


Fig. 15 — Mixes of 12½ lb in one type laboratory mixer or 25 lb in a second type mixer are prepared to a homogeneous consistency.

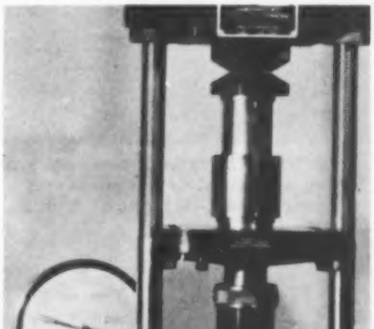


Fig. 16 — A solid metal cylinder piston with a self-aligning fixture attachment in a laboratory press is pressed into the cylinder against the sand to a 500 lb total pressure.

TABLE 15 — REPRESENTATIVE DATA SHEET FOR AN EXPERIMENTAL LABORATORY STUDY OF ONE FORMULATION (CO_2 MOLD STUDIES)

Sand	sand A in code designation Test: 122 standard formula
Sod. Sil.	binder 1, 51 degree Baumé, 1.8%
Additives	sugar, 2.0%; water, 0.5%; iron oxide, 2.0%
Mixing	5 min, 12.5 lb total
Mold Form	2¼ x 3 in. cylinder, hand rammed and pressed at 500 lb
Gassed	20 sec at 35 psi
Furnace Heat	2200 F.
Remarks	Immediately after gas S 95; shows poor resistance to high humidity. Compressive strength 0 after heat, good collapsibility

Storage hr.	Designation: Min. In Furnace	Designation: Sample No.	Compressive Strength: Before Heat	Compressive Strength: After Heat	S Hardness: After gas.	S Hardness: After stand. (5 hr)	S Hardness: After heat	General Appearance
			Normal relative humidity 38%					
5	0	1	2000			90		Excellent
5	0	2	2175			90		
5	0	3	2250			87		
5	5	4		0			0	
5	5	5		0			0	
5	5	6		0			0	
			Relative humidity 76%					
5	0	7	350			35		
5	0	8	350			60		
5	0	9	500			35		
5	5	10		0			0	
5	5	11		0			0	
5	5	12		0			0	
			Relative humidity 88%					
5	0	13	50			10		
5	0	14	25			30		
5	0	15	50			50		
5	5	16		0			0	
5	5	17		0			0	
5	5	18		0			0	

attachment to a 315 sand rammer. Flowability is only one parameter, and although good flowability is required for optimum cores and molds it must be combined with other properties such as strength, surface hardness and collapsibility after heat. These are all considered in determining best formulations and operating variables. The data compare equal with the flowability of sand formulations used in other molding processes.

Fig. 17 — The cylinder assembly is removed from the press, tapped lightly and gassed with a standard plunger gassing unit for 20 sec at 35 lb/sq in. pressure.

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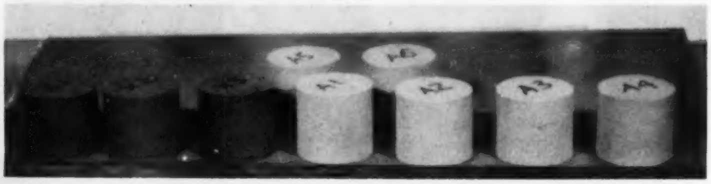

Fig. 18 — Completed cores ready for testing.

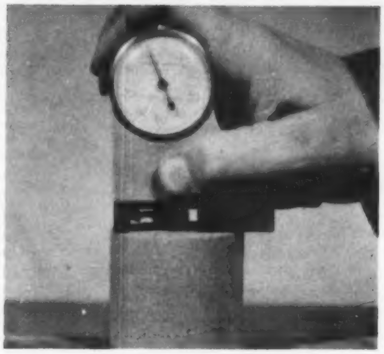

Fig. 19 — Surface hardness testing before heat.

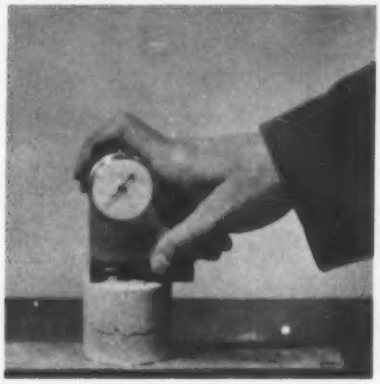

Fig. 20 — Surface hardness testing after heat.

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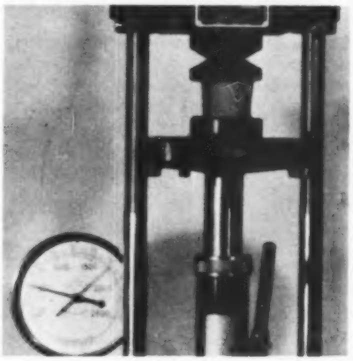

Fig. 21 — Cylinder being evaluated for compressive strength (pounds to crush) before heat application.

Fig. 22 — Heating cores in the furnace at 2200 F.

TABLE 16 — REPRESENTATIVE DATA SHEET FOR AN EXPERIMENTAL LABORATORY STUDY OF ONE FORMULATION (CO_2 MOLD STUDIES)

Sand	D in code designation
Sod. Sil	binder 1 51 degree Baumé, 3.5%
Additives	none
Mixing	4 min 10 lb batch
Mold Form	2.25 x 3 in. cylinder, hand rammed and pressed at 500 lb
Gassed	20 sec at 35 psi
Furnace Heat	2200 F., 2, 5, and 15 min
Remarks	Shows poor collapsibility

	Density		Compressive Strength			S Hardness		
Designation	Before Heat	After Heat	Before Heat	After Heat	After gas.	After standing	After Heat	General Appearance
				2 min				
25S	1.52		2150		72			Very good
26S	1.52	1.50		975	75	80	70	
27S	1.54	1.50		1800	70	81	68	
28S	1.49	1.45		1090	75	85	68	
				5 min				
29S	1.58		2425		81			
30S	1.53	1.50		975	68	90	65	
31S	1.51	1.50		1450	55	87	68	
32S	1.51	1.47		1950	65	83	68	
				15 min				
33S	1.54		2075		60			
34S	1.53	N/D		75	55	78	N/D	
35S	1.49	1.32		674	65	81	N/D	
36S	1.49	1.45		1915	60	72	68	

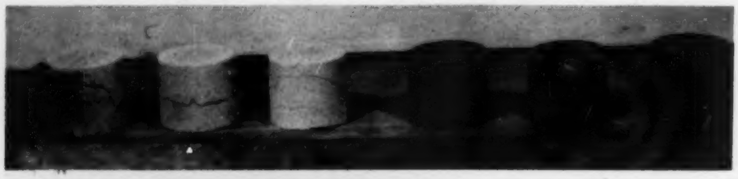

Fig. 23 — Cores after heat.

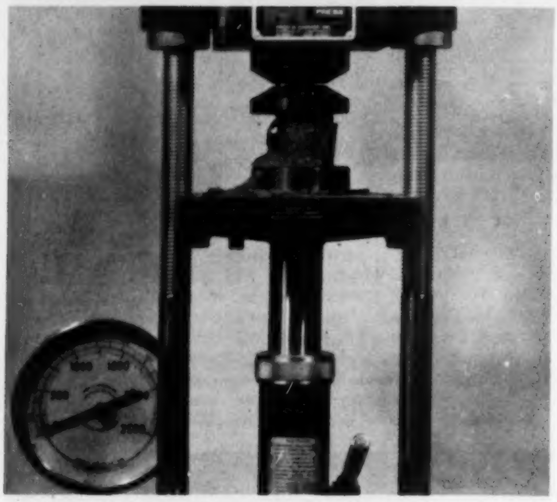

Fig. 24 — Testing compressive strength after heat.

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Fig. 25 — Cores in desiccators, relative humidities 35, 76 and 88 per cent.

Competition in Annual Apprentice, Trainee Contest Starts on Oct. 1

■ Foundry and patternmaking trainees begin competition Oct. 1 in all five divisions of the Robert E. Kennedy Memorial Apprentice Contest. All entries must be received by April 8, 1960.

The contest is open to any trainee with not more than five years patternmaking experience or four years molding experience. No restrictions are placed on AFS membership by either the contestant or his employer. All novices are eligible whether or not they are learning under an apprentice program. The amount and type of training has no bearing on eligibility and is not considered in the judging.

A contestant may compete in only one division of the national contest but may compete each year in any one division as long as he meets eligibility requirements.

Divisions open in national competition are metal patternmaking, wood patternmaking, iron molding, steel molding and non-ferrous molding. Three national winners are chosen in each division.

Rules are determined by the AFS Education Division and conducted by its Apprentice Contest Committee which selects and furnishes patterns and blue prints, determines the point-score basis and selects the judges.

Each contestant must observe the following: obtain a copy of the official rules and regulations, shall not examine the pattern or blueprint prior to entering competition and must have work certified.

The following applies to molding entries:

- The first casting poured from the first heat must be the only casting entered.
- All castings must be made in green sand molds only and must be blast-cleaned but not coated.
- Gates and risers must not be removed.
- Molding time starts when the contestant personally receives the pattern. Included in molding time are time spent in planning and study, closing the mold, clamping and weighting ready for pouring.

The following applies to pattern entries:

- Entries shall be coated only as specified on blueprint. Standard pattern colors shall be used.
- Time commences when the contestant personally receives the blueprint and shall include all planning and study.
- Shellac must be applied but may be still wet when the contestant relinquishes his pattern.

Entries in national competition may come from one of three avenues.

- Local chapter contests.
- Inter-plant contests.
- Individual plant contests.

1959-60 Regional Conference Schedule

Sept. 24-25	**Missouri Valley Regional Conference** University of Missouri School of Mines and Metallurgy, Rolla, Mo.
Oct. 1-2	**Empire State Regional Conference** Drumlin's Country Club, Syracuse, N.Y.
Oct. 2-3	**Northwest Regional Conference** Benjamin Franklin Hotel, Seattle.
Oct. 8-9	**Michigan Regional Conference** Pantlind Hotel, Grand Rapids, Mich.
Oct. 16-17	**New England Regional Conference** Massachusetts Institute of Technology, Cambridge, Mass.
Oct. 22-23	**Ohio Regional Conference** Deshler-Hilton Hotel, Columbus, Ohio.
Oct. 29-30	**Purdue Cast Metals Conference** Purdue University, Lafayette, Ind.
Nov. 20-21	**East Coast Regional Conference** Statler-Hilton, New York
Feb. 11-12	**Wisconsin Regional Conference** Hotel Schroeder, Milwaukee.
Feb. 18-19	**Southeastern Regional Conference** Thomas Jefferson Hotel, Birmingham

CONTENTS

Realign Administrative Duties of Officers for More Efficient Operations of Society

■ A re-definition of the duties of the AFS Executive Officers, the President and Vice-President, has granted greater power to the AFS Regional Vice-Presidents. This action by the Board of Directors transfers certain of the functions performed by Executive Officers to the Regional Vice-Presidents.

Officers will no longer preside over certain technical and committee events, enabling them to assume added duties such as representing AFS at meetings with societies with allied interests and to perform other services to the Society.

Regional Vice-Presidents will be the AFS representatives in their respective areas. They will conduct the regional administration meetings with the assistance of the Central Office and during the year will visit chapters in their area or meet with chapter chairmen.

The change is designed to give a closer relation between the central organization of AFS and the chapters and to permit Executive Officers to serve more effectively.

Following are the Regional Vice-Presidents, chapters and chapter contacts:

REGION 1

Regional Vice-President: A. A. Hochrein.

Chapters: Connecticut, New England, Metropolitan, Philadelphia, Chesapeake, Piedmont.

Directors: H. G. Stenberg, New England, Connecticut.
A. A. Hochrein: Chesapeake, Philadelphia.
D. E. Matthieu: Piedmont, Metropolitan.

REGION 2

Regional Vice-President: Wm. D. Dunn.

Chapters: Eastern New York, Central New York, Rochester, Western New York, Eastern Canada, Ontario, Pittsburgh, Northwestern Pennsylvania.

Directors: W. H. Oliver, Western New York, Northwestern Pennsylvania, Pittsburgh.
A. J. Moore: Eastern Canada, Ontario.
W. D. Dunn: Central New York, Eastern New York, Rochester.

REGION 3

Regional Vice-President: Fred J. Pfarr.

Chapters: Northeastern Ohio, Canton, Central Ohio, Toledo.

Directors: F. J. Pfarr, Northeastern Ohio.
*D. L. Colwell: Central Ohio, Toledo.
R. E. Mittlestead: Canton.

REGION 4

Regional Vice-President: Richard R. Deas, Jr.

Chapters: Detroit, Saginaw Valley, Central Michigan, Western Michigan, Cincinnati, Central Indiana, Michiana.

Directors: C. E. Nelson, AFS President: not assigned.
R. R. Deas, Jr.: Cincinnati, Central Indiana.
D. W. Boyd: Central Michigan, Western Michigan, Michiana.
L. J. Pedicini: Detroit, Saginaw Valley.

REGION 5

Regional Vice-President: Hillard M. Patton.

Chapters: Chicago, Wisconsin, Twin City, Central Illinois, Northern Illinois-Southern Wisconsin, Quad City.

Directors: N. J. Dunbeck, AFS Vice-President: not assigned.
*C. A. Sanders: Chicago, Quad City.
*A. M. Slichter: Central Illinois.
H. M. Patton: Twin City.
N. N. Amrhein: Wisconsin, Northern Illinois-Southern Wisconsin.

REGION 6

Regional Vice-President: Webb L. Kammerer.

Chapters: Corn Belt, Mo-Kan, St. Louis, Timberline, Tri-State, Texas, Mexico, Mid-South, Tennessee, Birmingham.

Directors: L. H. Durdin: Birmingham.
K. L. Landgrebe, Jr.: Tennessee, Mid-South.
W. L. Kammerer: St. Louis, Mo-Kan, Corn Belt, Timberline.
Jake Dee: Texas, Tri-State, Mexico.

REGION 7

Regional Vice-President: James N. Wessel.

Chapters: Southern California, Oregon, Utah, Northern California, Washington, British Columbia.

Directors: J. R. Russo: Northern California, Southern California, Utah.
J. N. Wessel: Washington, Oregon, British Columbia.

* Director-at-large.

Schedule Meetings for All Districts

■ Regional administration meetings will be held in each of the Society's seven districts during 1959-60. Regional Vice-Presidents as "AFS Representatives" will preside at the meetings designed to promote closer cooperation between the AFS Board of Directors and chapters.

Among subjects to be discussed are chapter affairs, membership, regional conferences, AFS developments, recommendations to the Board of Directors and regional news and events. A luncheon or dinner is held with chapters offices from the region attending.

AFS Vice-Presidents are:

REGION	AREA	VICE-PRESIDENT
1	East	A. A. Hochrein
2	East-Central	W. D. Dunn
3	Central	F. J. Pfarr
4	West-Central	R. R. Deas, Jr.
5	North-Central	H. M. Patton
6	South-Southwest	W. L. Kammerer
7	Pacific Coast	J. N. Wessel

1959-60 Schedule

Region 1 — Nov. 12 (Tent.)
New York

Region 2 — Sept. 30
Syracuse, N.Y.

Region 3 — Oct. 21
Deshler-Hilton Hotel, Columbus, Ohio

Region 4 — Oct. 28
Purdue University, Lafayette, Ind.

Region 5 — Nov. 13
Hotel Sherman, Chicago.

Region 6 — Oct. 30
Holiday Inn, St. Louis.

Region 7 — Oct. 1
Benjamin Franklin Hotel, Seattle.

committees in action

AFS Currently Sponsoring 10 Basic Research Projects

■ Ten AFS-sponsored research projects are currently active. Additional research programs may be initiated later.

Most projects are receiving financial support from the Society. Others are conducted on a cooperative basis by committee members and their organizations without cost to the Society except for special equipment or supplies.

The research projects:

Gray Iron Research

A Study of the Theory of Gating and Risering of Gray Iron and Its Practical Application: Several progress reports have been submitted at Conventions. Progress report on several years' work is being prepared and will be published as separate report later in year. Research conducted at Case Institute of Technology.

Investigation to Establish the Feeding Distance of Gray Iron Castings: Project initiated at beginning of fiscal year. Up to present time simple geometric shapes have been used. Work will continue with more complex configurations. It appears that in a completely rigid mold, gray iron can be fed relatively infinite distances.

Brass & Bronze Research

Pressure Tightness and Feeding Distance of 85-5-5-5 Bronze Castings: Being conducted at the University of Michigan under direction of Prof. R. A. Flinn. A progress report was made at 1959 Convention. It is hoped to continue program on somewhat expanded basis.

Light Metals

Thermodynamics of Casting Solidification of Light Alloys: Although under supervision of Light Metals Division Research Committee, it is under contract at Battelle Memorial Institute by the Ordnance Corps of the Department of the Army. Progress report submitted at 1959 Convention. Research establishes feeding distances possible with light alloys from risers of varying size and different locations.

Malleable Research

For past year research has been in progress at University of Wisconsin under direction of Prof. R. W. Heine. Investigation being made in possibility of casting heavy sections of malleable castings without the presence of primary graphite in the white castings. First progress report made at 1959 Convention. Fundamental information has been developed and research holds promise of excellent information for malleable foundrymen.

Steel Research

A preliminary investigation into the cause and elimination of "snotter" defect in steel castings was initiated last fall at University of Michigan under director of Prof. R. A. Flinn. Progress report made at 1959 Convention. Research has established origin of defect and work now in progress to develop means for its elimination.

Heat Transfer Committee

Committee in cooperative effort with Aluminum Co. of America and Canada Iron Foundries, Ltd., is in process of establishing heat losses in gating systems of different shapes. Two cooperating companies are providing services and facilities without cost.

Sand Division

Grading, Fineness & Distribution Committee: As result of cooperative effort by its members has disclosed basic information relative to segregation in handling of dry molding sands. Report and motion picture have been developed by committee, presently in cooperation with Manley Sand Co., Rockton, Ill. Research was conducted at no expense to Society. Committee also preparing report on proper procedures for sampling non-metallics. Work in developing information was also on cooperative basis without expense to Society. Report will be presented at 1960 Convention.

Physical Properties of Iron Foundry Molding Materials at Elevated Temperatures Committee. Working on the establishment of correlation between casting surface and hot properties of molding sands. A cooperative effort on part of committee with Society paying only for materials required.

Bakeability Test Committee: Current working cooperatively on project to develop suitable core bakeability test.

Malleable Division Reorganization

■ Considerable reorganization has been effected in the Malleable Division following a meeting of the Executive Committee in May.

Among the changes are:

- Appointment of F. B. Rote, Albion Malleable Iron Co., Albion, Mich., and H. J. Heine, Malleable Founders Society, Cleveland, as members-at-large to serve on the Executive Committee.
- The old Controlled Annealing Committee and the old Pearlitic Committee were combined to form a new Heat Treatment Committee (6D) under chairmanship of C. R. Sorenson, National Malleable & Steel Castings Co., Cicero, Ill.

Three new committees were formed.

- Casting Design Committee (6E)—Chairman, Joseph W. Beckham, Texas Foundries, Inc., Lufkin, Texas.
- Finishing & Inspection Committee (6G)—Chairman, Oral K. Hunsaker, Dayton Malleable Iron Co., Dayton, Ohio.
- Molding Materials & Methods Committee (6H—Chairman, Prof. R. W. Heine, University of Wisconsin, Madison, Wis.

The Executive Committee of the Malleable Division consists of the following:

F. W. Jacobs, Texas Foundries, Inc., Lufkin, Texas, Division Chairman.

L. R. Jenkins, Wagner Castings Co., Decatur, Ill., Division Vice-Chairman, Chairman, Program & Papers Committee.

Eric Welander, John Deere Malleable Works, East Moline, Ill., Chairman, Round Table Luncheon Committee.

C. F. Joseph, Central Foundry Div., GMC, Saginaw, Mich., Chairman, Research Committee.

C. R. Sorenson, National Malleable & Steel Castings Co., Cicero, Ill., Chairman of Heat Treatment Committee.

J. W. Beckham, Texas Foundries, Inc., Lufkin, Texas, Chairman, Casting Design Committee.

W. C. Truckenmiller, Albion Malleable Iron Co., Albion, Mich., Chairman, Melting Committee.

O. K. Hunsaker, Dayton Malleable Iron Co., Dayton, Ohio, Chairman, Finishing & Inspection Committee.

R. W. Heine, University of Wisconsin, Madison, Wis., Chairman, Molding Materials & Methods Committee.

H. J. Heine, Malleable Founders Society, Cleveland, member-at-large.

F. B. Rote, Albion Malleable Iron Co., Albion, Mich., member-at-large.

New Foundry Core

by
A. Dorfmueller, Jr.
Archer-Daniels-Midland Co.
Cleveland

Many new processes have been presented to the American foundryman during the past few years. Some of the newer processes presented for application in the core room are the CO_2 process, the air setting process, the shell core process, and more recently the complete air setting process which requires no baking.

■ THE CO_2 PROCESS has gained wide aceptance and is presently being used to some degree in over 30 per cent of the foundries in this country. The process is relatively simple to put into production, control is not particularly critical, and the applications are broad. The major applications for the CO_2 process are medium sized, low production cores, non-ferrous (particularly in the field of aluminum and magnesium castings) and certain tough steel foundry applications. The major problems in the CO_2 process are as follows:

1) *Low Strengths.* Since the core strengths range from 50 to 100 lb per sq in., this process can only be applied to those cores where low strength levels can be tolerated.
2) *Stickiness.* Since the base binder will air dry it is necessary to use the proper partings and control the core mix so as to keep the amount of binder at the absolute minimum.
3) *Collapsability.* Since the base binder of the CO_2 process is sodium silicate, an inorganic material, organic materials must be added to the core mix for collapsability. Some typical materials used are seacoal, pitch, wood flour, cereal flour and dektrene.
4) *Hot Deformation.* Sodium silicate becomes plastic in the upper temperature ranges. This is an extreme problem in steel foundry practice. Additions, such as iron oxide, fire clay, or the use of zircon sand help alleviate this condition.

■ THE SHELL CORE PROCESS has gained wide acceptance in the automotive field and also in the smaller production foundries. This process offers a fast method of making production and semi-production cores. The major advantages are the elimination of green handling, baking and storage problems of conventional oil sand cores.

The two major problems of the shell core process are:

1) *High cost of Pattern Equipment.* Cast iron pattern equipment is recommended for shell core production, limiting the application to high and medium production jobs where the cost of the equipment can be amortized over the long production. When figuring savings, the cost of the drier equipment and core plates, which would be necessary with conventional practice, must be considered. This last phase opens the application of shell cores in the field of complex, highly intricate

Efficiency in Materials Handling

by R. J. Geitman,
Link-Belt Co.,
San Francisco, Calif.

HANDLING BULK MATERIALS accounts for approximately 40 to 50 per cent of the total hours expended in the modern foundry. This is true in both small as well as large foundries. It is estimated that about 150 to 200 tons of material must be handled to produce one ton of good castings.

The proper application of conveyors for transporting and processing materials is most important in providing a uniform flow of material through the mechanized foundry. To put it another way—good engineering and proper layout design is just as important as the equipment selected.

FLEXIBILITY is of utmost importance in your conveyor mechanization program. Also the foundry must operate economically at half capacity as well as at full or over capacity.

Regardless of size, foundries should start with a carefully considered overall plan, even though economics of complete mechanization cannot be foreseen immediately. Thus units may be installed step by step, always following the over-all plan. Allow for readjustment and careful selection of work to be placed on the mold and sand handling system. This step-by-step approach is often better even though the economics of complete mechanization are indicated in the beginning. You can call this programing, if you like.

Because of tremendous savings in floor space by the use of mechanical mold handling equipment it is usually paramount to consider this area first. Mold handling requires flexibility, particularly in the small foundry, because of the wide variety of work that must be handled.

SEVERAL FUNDAMENTAL STEPS should be considered when formulating a materials handling system in any foundry:

1) An accurate analysis must be made of capacities required to meet sales potential.
2) A careful study should be made of present equipment, including building facilities.
3) The conveyor layout should be developed to produce a straight-line flow.
4) After a desirable flow has been finally established, a more detailed layout can then be developed. Keep in mind that flexibility is of utmost importance in development of the over-all conveyor layout from raw materials to finished products.

PROPER SELECTION of conveyors in the modern mechanized foundry makes it possible to lower unit costs, increase production, conserve man power and building space and improve working conditions.

Plan your foundry mechanization with an over-all picture of the complete operation from raw material to finished casting. All departments can then take full advantage of the investment without interference in the flow of materials.

Every foundry is different and presents its own problems which should be studied individually with the help of engineers who have had experience in mechanization of a wide variety of foundries.

Editor's Note: *This article contains highlights excerpted from a talk presented at the* 1958 *Northwest Regional Conference.*

Processes

core work where core assembly and drier costs are quite high.

2) *High Sand Costs*. The basic sand mix for the shell core process is considerably higher in cost when compared to conventional core practices. This can be off-set by using the process in applications where hollow cores may be used. By using coarse sand, 60 to 80 AFS fineness, resin additions as low as 2 per cent on a solids basis can be used. Where this type of sand will supply casting finish acceptable to the customer it can be used economically.

■ THE AIR SETTING PROCESS has come into wide acceptance, particularly in heavy job work such as machine tool, automotive die work and the production of heavy equipment. This process can basically be applied to any particular core where the normal fabrication time would exceed one-half hour. The savings which can be expected on this type of core work are: up to 80 per cent less fabricating time, up to 50 per cent less baking time, and up to 50 per cent less cleaning time. Air setting binders have also been used successfully as a molding media. The major problems with this process are:

1) *Control*. Minor variations in the addition of the catalyst or the base binder will make major variences in the working time of the sand mix. It, therefore, becomes a necessity to measure all materials accurately. By having sufficient dry sand storage, the problem of varying temperatures of the sand can be minimized. Separate mixing equipment is desirable to eliminate contamination.
2) *Producton Scheduling*. Since the sand has a definite bench life, production scheduling is an absolute necessity. A major revision on production control is required to successfully use the air setting process.
3) *Penetration*. Since the major application of the air setting process is on large core work, penetration is a possible problem. By controlling grain distribution of the sand and through the use of inorganic additives such as silica flour, iron oxide and fire clay this problem can be minimized. On extremely tough applications the use of zircon sand should be considered.

■ THE NEW GROUP OF AIR SETTING BINDERS which have been designed to completely eliminate baking are being introduced on a limited scale to the foundry market at the present time. These materials are basically resinous in nature and react with an acid catalyst to completely set the binder at room temperature. These binders are used on the same applications as the conventional air setting binders; however, they have the added advantage that no baking is required. Another practical application for this material is as a substitution for the dry sand facing used in fabrication of heavy castings.

All of these processes are new tools to be used in a modern foundry. When used properly they can result in better castings at lower costs. Evaluate these new tools in your foundry and see where they apply.

Editor's Note: *This article contains highlights excerpted from a talk presented at the 1958 New England Regional Foundry Conference.*

Sulphur Removal

S. L. Gertsman
Department of Mines & Technical Surveys, Ottawa, Ont.

■ Low sulphur contents permit more scrap to be used in the gray iron charge and a saving of nodularizing agent when making ductile iron.

DESULPHURIZING AGENTS Tests were conducted in which various desulphurizing agents were added to the tap stream of induction melted iron poured at 2750 F. The desulphurizing efficiency indicated that sodium hydroxide was the best reagent, followed by sodium carbonate, calcium carbide, calcium cyanamide and lime.

CAST STEEL In cast steel low sulphur contents give fewer difficulties due to grain boundary sulphides. The incidence of hot tearing is reduced. Low sulphur levels are necessary for good low temperature impact properties in low alloy steels.

MAGNESIUM Preliminary work was carried out with pure magnesium and magnesium alloys. These were added to the metal surface, to the tap stream, to the ladle before the tap, and beneath the metal surface in a plunging cup.

It was evident that a more friable and less dangerous material should be used. To suit these requirements a 50 per cent aluminum- 50 per cent magnesium alloy was developed. This was used in a mixture with lime.

LADLE INJECTION Ladle injection of acid electric steel reduces the sulphur content up to 40 per cent. The usual injected charge consists of 18 lb per ton calcined lime and 6 lb per ton Al-Mg alloy. This mixture is carried into the metal by argon gas. The injection time takes 30 seconds to 1 min and 30 seconds for 500 lb of steel.

ACID AND BASIC When acid steel was lanced in the furnace, sulphur reductions were obtained but a complex double slag procedure was required and the furnace tests were not as successful as the ladle tests. Basic electric steel, however, was desulphurized quickly and efficiently by injecting 24 lb per ton calcined lime and 6 lb per ton Al-Mg alloy into molten steel, held under a basic slag in the arc furnace, immediately prior to tapping.

LOW SULPHUR The sulphur content of the steel was lowered from an initial 0.020 per cent to 0.008 per cent. Sufficient deoxidation occurred during injection to allow casting without further addition of aluminum to the ladle.

Editor's Note: *This article contains highlights excerpted from a talk presented at the 1958 AFS All Canadian Conference.*

AMERICAN FOUNDRYMEN'S SOCIETY

Training and Research Institute

September 1, 1959
Thomas Founder, Pres.
Modern Foundries, Inc.
Yourtown, U. S. A.

Dear Tom:

Jack Smith had a close one the other day. Remember that dusty condition at his shakeout? Well the State factory inspector came over and said his collector was too small. He was given 60 days to get a bigger one. The lowest bid was $15,000. He was going to sign the order today when Bob Jones from the Squirrel Cage Fan Co. happened to stop in. He took a look and found the fan running backwards . . . delivering only 60 per cent of the air. Electrician switched the wires and Jack saved $15,000. Reminds me of the time I hooked a 220-volt vacuum cleaner to a 110-volt line–got only half the suction.

I was thinking . . . if we only knew more about this kind of thing. Remember Jim White's plant? He installed unit heaters and didn't know the roof ventilators would pull out the hot air before it warmed the men. Cost him plenty! . . . And old Bill Black put in a bag collector to exhaust a muller mixing bentonite, water and sand. The damp bentonite sealed off the bags and Bill had to trade it in for a wet type collector. Cost him $5000 extra.

Joe Brown really laughed at that one but old Bill had the last laugh when he heard Joe bought some unit-dust collectors for the cleaning room–didn't know they were forbidden by State law. He had to sell 'em for half price.

You pulled a few boners yourself, Tom. Remember when you bought the sound-absorption material instead of sound-reflective material to insulate the noise of a tumbling barrel from the shop. You didn't know sound-absorption material is like a blotter and lets the sound soak right through.

Yes Tom, you, Jack, Jim, Bill and Joe–all of you are always trying to reduce scrap castings but what are you doing about these costly boners, NOW, TODAY? That's why I'm writing to you.

Why not register one or two key men for the training course outlined on the opposite page? Look at what they're teaching! . . . and what a faculty! You'd think nothing of spending $60 to throw a party. Yet for that amount your man gets three days' instruction designed to eliminate or reduce costly errors. Price includes all instructional materials and lunches.

Maybe I'm crazy but if you don't take advantage of this, I think you are.

Sincerely,

Herb

Herbert J. Weber, *Director, AFS Safety, Hygiene and Air Pollution Control Program*

HJW:fd

P.S. Tom, to make it easier for you, fill out the bottom of this letter and return to me. I'll handle it from there.

Please register these men for the T&RI-AFS Course: Cutting Hidden Costs.

Name ____________________ Title ____________________
Name ____________________ Title ____________________
Signed ____________________ Company ____________________
$______ Enclosed (at $60 tuition per man) Address ____________________

Make checks payable to AFS TRAINING & RESEARCH INSTITUTE

AMERICAN FOUNDRYMEN'S SOCIETY

Training and Research Institute

Hidden Non-Production Factors Swell Casting Costs

MONDAY OCT. 5

8:30—9:00 am

REGISTRATION

9:00—9:15 am

ORIENTATION

Hamilton Hotel, Chicago.
Ralph Betterley, T&RI—AFS Training Supervisor.

9:15—10:15 am

WORKMEN'S COMPENSATION

1) History
2) Philosophy
   a. Wage loss concept
   b. Common law action
3) Types of Compensation Laws
   a. State fund
   b. Compulsory coverage
   c. Elective coverage
4) Insurance
   a. Principle of
   b. Cost
   c. Determination of premium
   d. Self-insurance
5) Employers Liability
6) Statutory Provisions
   a. Second injury fund
   b. Schedules
7) Inequities in the condition "arising out of and in the course of employment"
8) Industrial Commission — How it Functions

J. J. Bloomquist, Branch Legal, Mgr. Employers Mutuals of Wausau

10:15—10:30 am Recess

10:30—Noon

OCCUPATIONAL DISEASES

1) Kinds
   a. Silicosis
   b. Siderosis
   c. Lead poisoning
   d. Metal fume fever
   e. Beryllium poisoning
   f. Dermatitis
2) Treatment
3) Aluminum Therapy
4) Facts and Fallacies Concerning Occupational Disease

Eugene L. Walsh, M.D. Med. Director, International Harvester Co.

1:00—1:45 pm

GENERAL PRINCIPLES OF FOUNDRY VENTILATION

1) Basic Physics
2) General Exhaust
3) Intermediate Exhaust
4) Local Exhaust
5) Make up Air
6) Recirculation

Herbert J. Weber, Director SH&AP AFS

1:45—2:15 pm

EXHAUST HOODS

1) Design
2) Velocity Contours
3) Types
4) Applications in the Foundry

Herbert J. Weber, AFS

2:15—2:45 pm

EXHAUST HOODS—Motion Picture

2:45—3:00 pm

RECESS

3:00—4:15 pm

FANS—A Demonstration

1) Types
2) Applications
3) Fan Connections
4) Fan Arrangements

Wm. Tracy, Mgr. Sturtevant Div., Westinghouse Electric Corp.

TUESDAY OCT. 6

9:00—10:00 am

DUCT WORK EFFICIENCIES — A Demonstration

Kenneth Robinson, Ventilation Engineer, General Motors Corp.

10:00—10:15 am

RECESS

10:15—11:00 am

THE RIGHT AND WRONG WAY OF HEATING A FOUNDRY

Kenneth Robinson, Ventilation Engineer, General Motors Corp.

11:00—Noon

RADIANT HEAT—A Demonstration

1) Basic Physics
2) Application of Radiant Heat Laws
3) Practical Methods of Controlling

George Stoecker, Industrial Hygienist, General Motors Corp.

12:00—12:15 pm

RADIANT HEAT—Motion Picture

1:15—2:45 pm

DUST COLLECTORS

1) Types
2) Applications
3) Advantages and Disadvantages of Various Types
4) Comparative Efficiencies
5) Comparative Costs

David Stephan, Phd. U. S. Public Health Service.

2:45—3:00 pm

RECESS

3:00—4:00 pm

TESTING AND MAINTENANCE OF EXHAUST SYSTEMS

1) Testing an Exhaust System
   a. Testing instruments and use
   b. Procedure
2) Maintenance of Ventilation Equipment
   a. Common trouble
   b. Prevention of breakdown

Kenneth M. Smith, Chief Maintenance Engineer, Caterpillar Tractor Co.

WEDNESDAY OCT. 7

9:00—10:15 am

IMPACT OF NOISE ON COMPENSATION

1) Factors in Compensability of Hearing Loss
2) New York Precedent
3) Wisconsin Precedent
4) Status in Other States
5) Economic Impact
6) Solutions in Effect and Proposed

Floyd E. Frazier, National Association of Mutual Casualty Companies

10:15—10:30 am

RECESS

10:30—10:50 am

PHYSICS OF NOISE

H. J. Weber, AFS

10:50—11:25 am

PHYSIOLOGY OF HEARING AND HEARING LOSS

1) How We Hear
2) How Hearing is Impaired
3) Effects of Excessive Noise
4) Audiometry
   a. What it is
   b. Importance of
   c. Pre-placement and periodic audiograms

Paul Whitaker, M.D., Med. Director, Allis-Chalmers Mfg. Co.

11:25—Noon

FOUNDRY NOISE EXPOSURES

1) Damage Risk Criterion
2) Design Base Line
3) Noise Levels at Typical Foundry Operations

H. J. Weber, AFS

1:00—2:00 pm

ENGINEERING CONTROL OF NOISE

1) Fundamental Principles
2) Practical Methods in Foundries

H. J. Weber, AFS

2:00—2:30 pm

SUMMATION OF THE COURSE

1) General Review
2) Salient Points

Ralph Betterley, T&RI-AFS

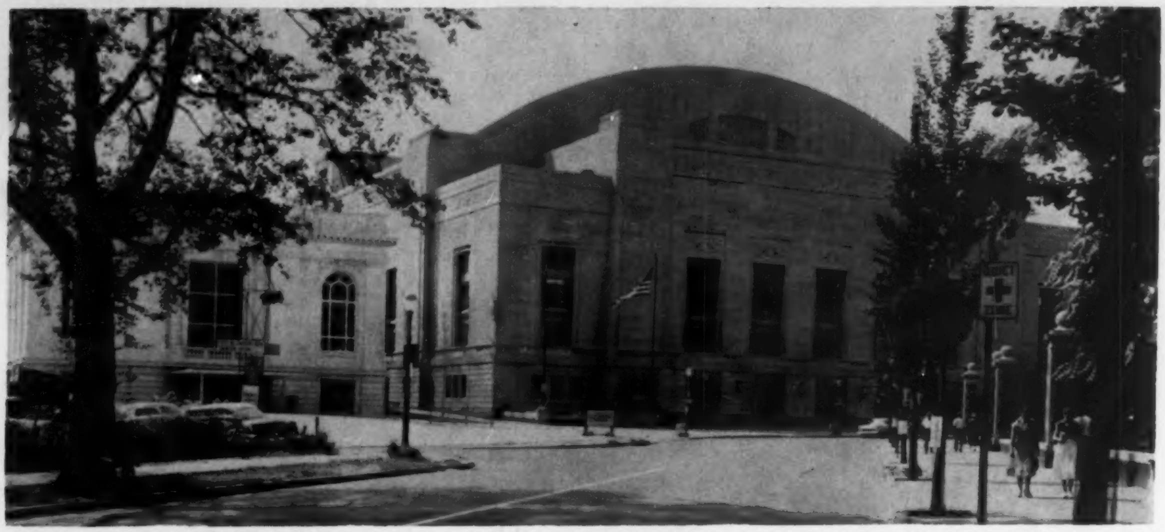
2:00—3:00 pm

ACHIEVEMENT TEST

(True—False)

$60.00 Registration Fee Includes All Instruction Material and Lunches

1960 Foundry Show to Open Door to Future



Philadelphia, site of the first AFS Convention in 1896, will be host for the seventh time, May 9-13, 1960. The **64th Castings Congress & Foundry Show** will be held in the air-conditioned Philadelphia Convention Hall.

■ Philadelphia, site of many historical events, will once more serve as the threshhold for progress—progress in the exploding foundry technology. Dedicated to the belief that nothing remains permanent but change, the 1960 AFS Foundry Show, May 9-13 at Philadelphia, will determine the future buying habits of many foundries.

Ways and means of meeting the changing needs of customers . . . combating competition . . . enlarging the castings market . . . these are the three important challenges facing the foundry industry today. How this can be done will be demonstrated at the Foundry Show.

Quality castings at competetive prices will be the key to success in the Soaring 60s. Equipment, supplies and processes will show how to cast to closer dimensional tolerances, with more precise control of mechanical properties and manufacturing costs.

At the first Convention of the Society, held 64 years ago in Philadelphia, Theo. P. Search, president, National Association of Manufacturers, stated:

"The man who does not keep closely in touch with his competitors today is likely to find himself far behind in the race. Those who know the most, those who are the most progressive in their business are the most willing to acquire new ideas which will place them still further in the lead."

These words of 1896 are still in tune with the times.

Floor plans, application blanks and general information on the 1960 Castings Congress and Foundry Show were mailed Sept. 1.

Northwest Regional Foundry Conference Deals with Improving Casting Quality and Production

The 10th Annual AFS Northwest Regional Conference will be held in Seattle, Wash., Oct. 2nd and 3rd. Conference chairman is W. K. Gibb, Atlas Foundry & Machine Co., Tacoma, Wash. Harold Wolfer, Bremerton Navy Yard, is Conference program chairman. The AFS Washington Chapter will host the Conference.

Most of the fundamental subjects effecting the production of better and improved castings will be covered during the two-day meeting. Here is a brief list of speakers and their subjects:

Prof. W. M. Miller, University of Wasington, *Hydraulics for the Practical Foundryman;* Frank Brewster, Brumley-Donaldson Co., Los Angeles, *West Coast Foundry Sands;* A. A. Belusko, ESCO, Portland, Ore., *Sand Practices at Electric Steel Foundry Co.;* E. A. Lange, U. S. Naval Research Lab., *Factors Affecting the Performance of Mold and Core Sand;* David Matter, Ohio Ferro-Alloys Corp., *Production Techniques for Ductile Iron and Problems of the New Producer;* Alan DeRoss, Kaiser Aluminum & Chemical, *High Strength Aluminum Alloys;* Fred Wiehl, Federated Metals Div., American Smelting & Refining, *New Foundry Developments;* Richard Grogan, Archer-Daniels-Midland, Los Angeles, *New Core Practices;*

Lovick Young, A-1 Steel and Iron Foundry, Vancouver, B. C., *Steel Melting;* Leroy Fink, ESCO, Portland, Ore., *Induction Melting of Steels;* and Edward Rommen, Bremerton Navy Yard, *Pattern Rigging.*

Special programs and activities are being formulated for the lady visitors.

Matthieu Becomes New AFS Director

■ Donald E. Matthieu, vice-president, Wysong & Miles Foundry, Inc., Greensboro, N.C., has been elected as an AFS National Director by the Board of Directors to fill the unexpired term of Thomas W. Curry, Lynchburg Foundry Co., Lynchburg, Va., resigned.

Matthieu was one of the founders of the Piedmont Chapter and served as Chairman 1958-59. He has also been active in AFS technical activities. Formerly chief metallurgist for Alabama Pipe Co., Anniston, Ala., where he served as membership chairman of the Birmingham Chapter, he then joined the staff of Kerchner, Marshall & Co. in the Virginia area. Until affiliation with Wysong & Miles, Matthieu was assistant to the president, Richmond Foundry & Mfg. Co., Richmond, Va.

T&RI-AFS Shows How Foundries Can Reduce Casting Costs

■ How the metalcastings industry can achieve lower costs other than through production will be emphasized at the September and October courses presented in Chicago by the AFS Training & Research Institute.

A four-step program including patternmaking, product development and marketing, savings through safe practices, and preventative maintenance will stress departments in which many foundries can improve.

Patternmaking

Patternmaking, Sept. 16-18, covers basic principles and new areas and materials. In the study of wood patterns, factors are selection of lumber, importance and types of coatings and woodworking equipment. How use, design and casting specifications affect the choice and selection of production pattern equipment are to be evaluated. Items include size of casting run, casting specifications, design, method and ease of molding, core requirements and abrasion resistance of patterns.

Plaster and plastic patterns are to be studied including their advantages, limitations and production steps. Other subjects are core blowing, core box design and shell mold and shell core pattern equipment.

Marketing & Development

Marketing and development by the castings industry has been frequently cited as one of its major weaknesses. The T&RI course, Sept. 28-30, stresses that foundries must constantly improve their product not only to meet competitive methods but also to keep pace with changing customer needs.

Casting advantages will be analyzed and studied for incorporation into design. Consideration is given to the initial stage to perform its basic function, modification influence for reducing casting costs, stress analysis and a study of case histories. Studies will be made of the selection and construction of pattern equipment including types of patterns, pattern allowances, plaster and plastic patterns.

1959 T&RI-AFS Courses

Sept.-Oct.

Subject and Description — *Dates*

Patternmaking .... **Sept. 16-18**
Demonstration and instruction for patternmakers, foremen, supervisors, trainees, purchasers of castings, suppliers and management—materials, equipment, layout, allowances, construction techniques and recent trends. Emphasis placed on new materials, processes, techniques and their applications. Course PM1A, $80, Chicago.

Product Development & Marketing .... **Sept. 28-30**
Instruction course on product analysis from the design to the marketing of the finished product. Study will include: casting design, stress analysis, pattern selection, equipment, cleaning operations, cost analysis, casting processes, engineering properties of cast metals and sales promotion. Scheduled for all types of foundry engineers, sales engineers, technicians, supervisors, metallurgists and management. Course PDIA, $60, Chicago.

Cutting Hidden Costs .... **Oct. 5-7**
Demonstration and instruction course on savings that can be made through a knowledge of Workmen's Compensation, ventilation, radiant heat, occupational disease, safety in plant design. Plants have little control over insurance premiums. These costs represent only 25 per cent of the actual costs sustained. Informed management can control 75 per cent of these costs. Designed for top management, supervisors, engineers and safety men. Course SAF1A, $60, Chicago.

Preventive Maintenance .... **Oct. 26-28**
Intensive instruction on the "why" and "how" of a preventive maintenance program. Danger points in mechanized foundries having automatic and semi-automatic equipment. Cutting costs and reducing "down time" with an adequate maintenance program. Valuable assistance and guidance for foremen, supervisors, superintendents and management. Course PRM1A, $60, Chicago.

T&RI-AFS Building Committee Approves Plans

■ Approval of plans for the new AFS Training & Research Institute Training Center building was given July 20 by the T&RI-AFS Building Committee at a meeting held in Des Plaines, Ill.

Authorization was granted for the architect to proceed with preparation of detailed drawings and complete specifications required for the taking of formal bids.

Attending were H. Bornstein, Chairman, T&RI-AFS Trustees, F. C. Fluegge, International Harvester Co., Chicago; Alex Granath, National Engineering Co., Chicago; L. D. McDowell, American Steel Foundries, Chicago; R. A. Oster, Beloit Vocational and Adult School, Beloit, Wis.; member of the T&RI-AFS Building Committee, Wm. W. Maloney, T&RI-AFS Secretary; S. C. Massari, T&RI-AFS Director; Kenneth Holmes and Richard Fox, Holmes & Fox, architects, Des Plaines, Ill., and Arthur Bladen, engineering consultant, Chicago.

Industry-Education in Indianapolis

Gives New Life to High School Foundry

■ Modernization of facilities plus cooperation between school officials and local industry has revitalized the foundry and patternmaking courses at Arsenal Technical High School, Indianapolis.

Approximately 70 boys attend foundry classes with facilities equal to any high school in the country. Foundry courses are included in the metals trade curriculum during the first two years. Approximately one-third of the students complete the four-year program.

Preliminary planning for the new foundry, now in its second year, began in 1951 with a meeting between Public School and foundry leaders. It was prompted by a need for qualified supervisory and management personnel by Indianapolis casting plants.

A committee was appointed to determine what could be done to strengthen the program and attract students. Four foundrymen, all former chairmen of the AFS Central Chapter and all still active on the committee, represented foundries. They are: James A. Barrett, National Malleable & Steel Castings Co.; Robert Langsenkamp, Langsenkamp-Wheeler Brass Works, Inc.; Carl Schopp, Ewart Plant, Link-Belt Co.; and William Fitzsimmons, International Harvester Co.

School representatives were: H. L. Harshman, Assistant Superintendent of School; Ernest Thiel, Supervisor of Vocational Education; Alfred P. Smith, Supervisor of Industrial Arts; H. H. Walter, Vice-Principal, Arsenal Technical High School. George L. Lone was added to this group upon his appointment as Director, Shop Activities, Arsenal Tech.

Prof. H. S. Belman, Industrial Education Dept., Purdue University, served as chairman of the committee during its first year.

The following steps were undertaken:

- Making pupils and the school administration officials aware of the employment possibilities.
- Arranging field trips; these are still conducted.
- Survey of foundry activities.

Foundry facilities were described as adequate but not representative of modern methods. Recommendations, which were adopted, included: mechanical equipment for handling and conditioning sand, mechanical molding, sand testing equipment.

Indianapolis foundries contributed $1000 in addition to donating equipment or furnishing it at reduced cost.

A small demonstration cupola designed and built by National Malleable was used as the model for construction of a similar cupola by students in the metal trades shops. It has an operating capacity of 100 lb per hour.

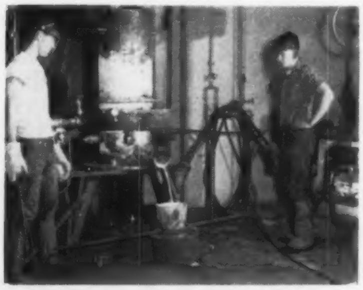
Harry Stone, foundry instructor, had no previous experience but has become well versed through summer employment in local foundries and attending AFS Instructor Seminars.

Pictures courtesy of Link-Belt Co., Ewart Plant.

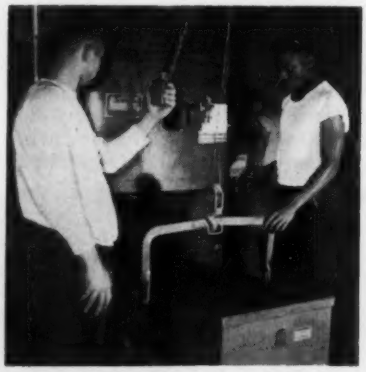
Foundry representatives **C. O. Schopp, J. A. Barrett, R. M. Langsenkamp, W. M. Fitzsimmons,** all former Central Indiana Chapter Chairmen.

School representatives: **Ernest Thiel,** assistant superintendent of schools; **Alfred P. Smith,** supervisor of industrial arts; **George L. Lone,** director, shop activities, Arsenal Tech.; **W. R. Eddy,** head, metal trades department, Arsenal Tech.

School also has tilting gas-fired furnace.



Tapping cupola made at school.



Arsenal equipment is modern.

Instructor Stone supervises sand testing in laboratory section.

International Congress Deals with Mutual Problems

■ An international exchange of technical information will attract foundrymen from most parts of the world to the 26th International Foundry Congress to be held Oct. 4-10 in Madrid, Spain.

The International, sponsored by the International Committee of Foundry Technical Associations, will devote three days to technical sessions and a fourth to meetings of the various International Committees dealing with foundry technical problems.

AFS will be represented by two official delegates, AFS National Director C. A. Sanders, American Colloid Co., Skokie, Ill., and AFS Technical Director S. C. Massari. Howard H. Wilder, Vanadium Corp. of America, Chicago, will present the official AFS exchange paper dealing with the use of inoculants and ferroalloys for the production of high-strength gray irons.

The International Foundry Congress program:

SUNDAY-MONDAY OCT. 4-5

10:00 am to 6:00 pm Congress Bureau open at headquarters (Delegacion Nacional de Sindicatos).

TUESDAY, OCT. 6

11:00 am Official opening session.
3:00 pm Sight-seeing tour of Madrid.
6:00 pm Reception of members by the Spanish Institute of Iron and Steel at its new facilities at University City.
10:00 pm Social evening entertainment.

WEDNESDAY, OCT. 7

9:00 am to 1:00 pm Technical sessions.
4:00 pm Visit to the Spanish Higher Council for Scientific Research, featuring both a lecture and reception.
7:00 pm Reception by invitation of the Municipal Corporation of Madrid in the Retiro Gardens.
9:00 am to 6:00 pm Special program for ladies.

THURSDAY, OCT. 8

Meetings of the Committees of the International Committee of Foundry Technical Associations.
10:00 pm Banquet for official delegates of the International Committees of Foundry Technical Associations. (Evening dress).
9:00 am to 6:00 pm Special program for ladies.

FRIDAY, OCT. 9

9:00 am to 1:00 pm Technical sessions.
4:00 pm Visit to the Empresa Nacional de Autocamiones, S.A.
10:00 pm Official closing banquet (evening dress).
9:00 am to 6:00 pm Special program for ladies.

SATURDAY, OCT. 10

9:00 am to 1:00 pm Technical sessions.
4:00 pm Formal closing sessions.

Solicit Papers for 1960 International

■ Official AFS exchange papers have been scheduled during 1960 at the meeting of the Institute of British Foundrymen and the International Foundry Congress.

C. F. Joseph, Central Foundry Div., GMC, Saginaw, Mich., will present the official exchange paper to the I.B.F. meeting at Malvern, England during June.

Papers are being solicited for the 1960 International Foundry Congress to be held Aug. 14-20 at Zurich, Switzerland. The theme of the International will be "Better working conditions and technical progress in the foundry." Papers should deal with recent researches in the foundry, modern foundry techniques or the man and the foundry. Titles of papers and names of authors must be available before Sept. 1, 1959.

Society Sponsors Two 1959 Exchange Papers

■ Two official exchange papers will be sponsored this year by AFS. Howard H. Wilder, Vanadium Corp. of America, Chicago, is the author of a paper discussing the use of inoculants and ferroalloys for the production of high-strength gray irons. This will be the official AFS exchange paper to the International Foundry Congress to be held in Madrid, Spain during October.

The second paper will be sent to the Institute of British Foundrymen in Australia which is celebrating its 21st year of existence. The paper deals with green sand principles controlling casting quality. The authors are E. H. King and J. S. Schumacher, Hill & Griffith Co., Cincinnati and Prof. R. W. Heine, University of Wisconsin, Madison, Wis.

C. K. Donoho Named as Society Representative

■ C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala., has been named as the AFS representative on the Inter-Society Corrosion Committee of the National Association of Corrosion Engineers. He replaces Dr. J. T. MacKenzie, Southern Research Institute, Birmingham, Ala.

Sigerfoos Assisting Yugoslavian Plants

■ Prof. C. C. Sigerfoos, Michigan State University, East Lansing, Mich., has been on a leave of absence, under assignment by the International Cooperation Administration, Yugoslavia.

He was working in the cities of Zelenznik, Ljubljana, Rijeka and Nis giving technical assistance in the fields of metallurgy, mechanization and quality control.

At a May meeting of the Rijeka Foundrymen's Club, Sigerfoos presented three films showing American cupola melting and mechanization.

Prof. Sigerfoos, Michigan State University, shown with Yugoslavian foundrymen during May. Sigerfoos showed movies demonstrating American methods.

Early Ordering Saves on 1959 Transactions

■ Pre-publication order forms for the 1959 annual TRANSACTIONS, Vol. 67, have been mailed to members. AFS members may obtain the publication for $8 if the order is returned with payment to AFS headquarters prior to Sept. 15. After expiration of the offer, members may obtain TRANSACTIONS for $10. Non-members are charged $15 at all times.

TRANSACTIONS includes all technical papers presented at the 1959 Convention with written and verbal discussions as well as many research and special committee reports.

Mailing date for TRANSACTIONS will be approximately January, 1960.

Purdue Conference Stresses Controls, Markets

■ Ferrous and non-ferrous section meetings, general sessions and a panel discussion will be used at the Purdue Metals Castings Conference to stress control practices and future markets.

The conference to be held Oct. 29-30 at Purdue University, Lafayette, Ind., is sponsored by the AFS Central Indiana and Michiana Chapters and Purdue University.

The program:

THURSDAY, OCT. 29

(Morning Sessions)

9:00 am Registration.

10:00 am Opening General Sessions, Conference Chairman Dallas F. Lunsford, Perfect Circle Corp., Hagers- *Welcome*: Dr. J. Hicks, Purdue University, Lafayette, Ind.
Response: AFS Regional Vice-President R. R. Deas, Jr., Hamilton Foundry & Machine Co., Hamilton, Ohio.

10:45 am General Session: Technical Chairman, Joseph B. Essex, Golden Foundry Co., Columbus, Ind.
Practical Application of the CO_2 Process: William E. Jones, Lester B. Knight Co., Chicago.

Noon Lunch.

(Afternoon Sessions)

1:30 pm Concurrent Sessions.
Non-Ferrous: Technical Chairman, Glenn Harrington, Williams Bros. Inc., Elkhart, Ind.
Melting of Copper-Base Alloys: F. L. Riddell, H. Kramer & Co., Chicago.
Ferrous: Technical Chairman, William M. Fitzsimmons, International Harvester Co., Indianapolis.
Carbon Control in Acid Cupola Operation, Wally Levi, Consultant, Radford, Va.

3:00 pm Concurrent Sessions.
Non-Ferrous: Technical Chairman, Thomas Hargitt, Light Metals, Inc., Indianapolis.
Gas and Its Control in Cast Aluminum Alloys: D. L. LaVelle, American Smelting & Refining Co., South Plainfield, N. J.
Ferrous Session: Technical Chairman, T. E. Smith, Central Foundry Div., GMC, Danville, Ill.
Metallurgy of Malleable Iron and Future Uses of Same: F. B. Rote, Albion Malleable Iron Co., Albion, Mich.

6:30 pm Banquet Dinner Meeting: Master of Ceremonies, Conference Program Chairman Howard B. Vorhees, manufacturers' agent, Mishawauka, Ind.
Back Drop for Survival: V. Dewey Annakin, Indiana State Teachers College, Terre Haute, Ind.

FRIDAY, OCT. 30

(Morning Sessions)

9:00 am General Session: Technical Chairman, Kenneth Bly, Fabricast Div., GMC, Bedford, Ind.
Applications for Cast Aluminum in the Automotive Industry: R. F. Thomson, General Motors Corp., Detroit.

10:15 am General Session: Technical Chairman Arden Pridgeon, Benton Harbor Malleable Industries, Inc., Benton Harbor, Mich.
Shell Cores: Robert Andrews, Demmler Mfg. Co., Kewanee, Ill.

11:30 am *How to Build a Scrap Pile*, Panel Session, Technical Chairman, Dallas F. Lunsford.
William M. Grimes, Gartland Foundry Co., Terre Haute, Ind.
William A. Rodefeld, Perfect Circle Corp., Hagerstown, Ind.
Robert Hull, Casting Service Corp., LaPorte, Ind.

Five Ohio AFS Chapters to Sponsor Regional

The Deshler-Hilton Hotel, Columbus, Ohio, will be the site of the Ohio Regional Conference Oct. 22 and 23. The conference, sponsored by the five AFS Chapters in Ohio, will be chaired by D. E. Krause, Gray Iron Research Institute, Inc., Columbus, Ohio. Dallas Marsh, Cooper-Bessemer Corp., Mount Vernon, Ohio, is program chairman assisted by a program committee of representatives of the other four Ohio Chapters.

The tentative program follows:

THURSDAY, OCT. 22

(Morning Session)

8:00 am Registration, lobby Deshler-Hilton Hotel

10:00 am General Session: *Engineering Education and the Foundry;* D. C. Williams, Chairman. Speakers: H. A. Bolz, Dean of Engineering, Ohio State University;
Prof. Mars G. Fontana, Chairman, Department of Metallurgical Engineering, Ohio State University.

10:45 am General Session: *Applications for the CO_2 Process in the Foundry,* Panel Discussion, Chairman, Edw. H. King, Hill & Griffith Company;
Four speakers, The CO_2 process for cores, stack molding, facings for heavy castings.

12:15 pm Luncheon: speaker, Marvin Homan, Ass't Director of Athletic Publicity.

(Afternoon Sessions)

2:00 pm Steel: *New Developments, Process in Melting and Ladle Practice; Electric Furnace;* Jerry Hathaway, Massillon Steel Castings Co., Massillon, Ohio.
Gray Iron and Malleable Iron: *Operation of Water Cooled Cupolas,* Mervin H. Horton, Deere & Company, Moline, Illinois.

2:00 pm Non-Ferrous: *Experiences in Melting Brass by Induction, Indirect Arc and Crucible Methods.* A. W. Bardeen and W. J. Amsbary, Ohio Brass Company, Mansfield, Ohio.
Maintenance: *A Sound Maintenance System Pays Off,* Speaker—Unconfirmed.

3:30 pm Steel: *Hot Tears in Steel Castings,* J. A. Rassenfoss, American Steel Foundries, East Chicago, Ill.
Gray Iron: *Inoculation—Control Tool for Acid and Basic Cupola Melting,* A. P. Alexander, International Harvester Company, Memphis, Tenn.
Non-Ferrous: *Gating and Risering Copper Base Alloys,* William Ball, Sr., R. Lavin & Sons, Chicago.
Cleaning of Castings: Subject & Speaker unconfirmed.

6:30 pm Banquet

FRIDAY, OCT. 23

(Morning Sessions)

8:00 am Registration

9:00 am Steel: *Metallurgy of Cast Steel, Heat Treatment, Inclusion Types, etc.,* C. K. Donoho, American Cast Iron Company, Birmingham, Ala.
Gray Iron: *Manufacturing Procedure and Economics Using Cold Set Oil Bond,* G. Johnstone, Jr., Johnstone Foundries, Inc.
Non-Ferrous: *Metallurgy of Aluminum and Magnesium,* E. E. Stonebrook, Aluminum Company of America, Cleveland.
Pattern: *Pattern Construction*—Subject and speaker to be confirmed.
Malleable: *Metallurgical production problems,* speaker and subject to be confirmed.

10:30 am Steel: *Sand,* George Vingus, Magnet Cove Barium Corp.
Gray Iron: *Risering of Gray Iron and Ductile Iron,* J. F. Wallace, Case Institute of Technology.
Malleable: *Solidification and Feeding of Malleable Iron,* B. C. Yearley, National Malleable and Steel Castings Co., Cleveland.
Non-Ferrous: *Permanent Molding Aluminum Alloys,* R. Petto, Jr., & R. Seher, Arrow Aluminum Castings Co., Cleveland.
Pattern: *Plastics and Plaster in Pattern Making,* speaker to be confirmed.

12:15 pm Luncheon: Speaker—Fred J. Pfarr, Lake City Malleable Iron Company—Cleveland, AFS Regional Vice President—Report on National Activities of AFS.

2:00 pm General Session: *Shell Molds and Cores,* Panel Discussion: Chairman, B. D. Claffey, G. H. R. Foundry Division, Dayton Malleable Iron Company, Dayton, Ohio.

chapter news

St. Louis Chapter members at the May meeting heard C. V. Nass, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago, discuss mechanization of molding. Shown are Technical Chairman **E. J. Bewig,** St. Louis Steel Castings Co., St. Louis, and speaker **Nass.**
—**H V. Boemer**

Northeastern Ohio Chapter members held their annual golf outing at the Barberton-Brookside Country Club in June. Shown during a rest from golfing are **Charles J. Jelinek** and **Eugene L. Buchman** of Ford Motor Co. Cleveland Foundry and **Anton Dorfmueller, Jr.,** Archer-Daniels-Midland Co., Cleveland. Conducting the drawings are **Henry Apthorp,** East Ohio Gas Co.; AFS National Director **F. J. Pfarr,** Lake City Malleable Co.; and **Howard E. Heyl,** Archer-Daniels-Midland Co. Third picture (below) shows members relaxing after dinner.
—**Sterling Farmer**

John V. Scherer, Pittsburgh Steel Foundry, first winner of the Pennsylvania Glass Sand Corp. golf trophy, receives the award from **John J. Brown,** Pennsylvania Glass Sand Corp. on right. Pittsburgh Chapter foundrymen compete for the trophy at their annual golf outing.

New **Western New York** officers: standing, Chairman **A. J. Heysel,** E. J. Woodison Co., Buffalo, N.Y.; seated left, Vice-Chairman **Edward J. O'Connell,** American Radiator & Standard Sanitary Corp., Buffalo, N.Y.; seated right, Secretary **Ronald E. Turner,** Queen City Sand & Supply Co., Buffalo, N.Y.
—**Don Kreuder**

June meeting of the **Oregon Chapter** was held at the West Linn Inn, West Linn, Ore. A short business meeting was held at which time chapter officers were installed. Following the meeting chapter members toured the Crown Zellerbach paper mill.

Eastern New York Chapter Holds Ladies Night

Eastern New York Chapter held its 2d Ladies Night in May. Shown are Chairman **R. Newton Williams,** Director **Gerard Poirier, Mrs. Poirier, Mrs. Theodore Carlson** and Vice-Chairman **Theodore Carlson.**

Chapter officers and directors shown at head table during **Eastern New York's** Ladies Night. Mr. and Mrs. **P. E. Noonan,** Mr. and Mrs. **R. N. Williams,** Mr. and Mrs. **T. O. Carlson.**
—Leonard C. Johnson

Wives of **Eastern New York Chapter** foundrymen who won door prizes at the chapter's Ladies Night held in May at Menands, N. Y.

afs | chapter meetings

SEPTEMBER

Birmingham District . . Sept 5 . . Cascade Plunge, Birmingham, Ala. . . *Annual Picnic.*

British Columbia . . Sept. 18 . . Leon's Restaurant, Vancouver, B. C. . . W. D. Chadwick, Manley Sand Co., *"Sand Segregation in the Foundry."*

Central Illinois . . Sept. 12 . . 497th Engineers, Groveland, Ill. . . *Annual Fish Fry.*

Central Michigan . . Sept. 16 . . Hart Hotel, Battle Creek, Mich.

Central New York . . Sept. 11 . . Drumlin's, Syracuse, N. Y.

Central Ohio . . Sept. 14 . . Seneca Hotel, Columbus, Ohio . . D. E. Krause, Gray Iron Research Institute, *"Cupola Operation."*

Chesapeake . . Sept. 25 . . Out Door Country Club, York, Pa. . . Visitation *at Cochrane Foundry, Inc., and American Chain & Cable Co., York, Pa. and Columbia Malleable Castings Corp., Columbia, Pa.*

Cincinnati District . . Sept. 14 . . Wigwam Restaurant, Cincinnati . . E. L. Key, Mexico Refractories Co., *"Foundry Refractories."*

Connecticut . . Sept. 22 . . Waverly Inn, Cheshire, Conn.

Corn Belt . . Sept. 18 . . Marchio's Restaurant, Omaha, Neb. . . O. J. Myers, Reichhold Chemicals, Inc., *"Air Setting Core Binders."*

Detroit . . Sept. 10 . . Wolverine Hotel, Detroit.

Mexico . . Sept. 14 . . Camara Industria Transformacion, Mexico, D. F.

Michiana . . Sept. 19 . . Elks Country Club, LaPorte, Ind. . . *Annual Picnic.*

Mid-South . . Sept. 11 . . Claridge Hotel, Memphis, Tenn.

Missouri Valley Regional Foundry Conference . . Sept. 24-25 . . University of Missouri, School of Mines & Metallurgy, Rolla, Mo.

Mo-Kan . . Sept. 17 . . Kansas City, Kans. . . O. J. Myers, Reichhold Chemicals, Inc., *"Air Setting Core Binders."*

New England . . Sept. 9 . . University Club, Boston.

Northeastern Ohio . . Sept. 10 . . Tudor Arms Hotel, Cleveland . . *Ferrous Group*: F. C. Barbour, Republic Steel Corp., *"New Developments in Cupola Melting Practice"; Non-Ferrous Group*: W. E. Sicha, Aluminum Co. of America, T. D. Stay, Reynolds Metals Co. and J. J. Kroecker, Permold Co., AFS *Film "Horizontal Gating Design"; Pattern Group: Moderator*, D. C. Hartman, Cove Pattern Works, *"Casting & Pattern Design to Reduce Cost."*

Northern California . . Sept. 14 . . Spenger's Cafe, Berkeley, Calif. . . W. D. Chadwick, Manley Sand Co., *"Sand Segregation in the Foundry."*

Northern Illinois & Southern Wisconsin . . Sept. 8 . . Morse Hills Country Club, Beloit, Wis.

Northwestern Pennsylvania . . Sept. 28 . . Amity Inn, Erie, Pa.

Ontario . . Sept. 25 . . Seaway Hotel, Toronto, Ont.

Oregon . . Sept. 16 . . Heathman Hotel, Portland, Ore. . . W. D. Chadwick, Manley Sand Co., *"Sand Segregation."*

Piedmont . . Sept. 4 . . Old Point Comfort Hotel, Newport News, Va. . . M. E. Annich, American Brake Shoe Co., *"Work Simplification."*

Pittsburgh . . Sept. 21 . . Webster Hall Hotel, Pittsburgh, Pa. . . F. G. Steinebach, Penton Publishing Co., *"Future of the Foundry Industry."*

Quad City . . Sept. 21 . . LeClaire Hotel, Moline, Ill.

St. Louis District . . Sept. 10 . . Edmond's Restaurant, St. Louis. . . L. E. Taylor, Ottawa Silica Co., *"Molding Sand Production."*

Southern California . . Sept. 11 . . Rodger Young Auditorium, Los Angeles . . W. D. Chadwick, Manley Sand Co., *"Sand Segregation in the Foundry."*

Tennessee . . Sept. 25 . . Wimberly Inn, Chattanooga, Tenn.

Texas . . Sept. 18 . . University of Houston, Houston, Texas . . Panel Discussion, *"Steel Ladle Practice."*

Texas, East Texas Section . . Sept. 25 . . Longview, Texas.

Texas, San Antonio Section . . Sept. 21 . . San Antonio Machine & Supply Co., San Antonio, Texas.

Timberline . . Sept. 16 . . Denver, Colo. . . O. J. Myers, Reichhold Chemicals, Inc., *"Air Setting Core Binders."*

Tri-State . . Sept. 11 . . Alvin Plaza Hotel, Tulsa, Okla.

Twin City . . Sept. 15 . . Jax Cafe, Min-

Continued on page 132

let's get personal

E. C. Jeter

E. E. Harkess

E. C. Jeter . . . has been named manufacturing manager of foundries, Engine and Foundry Div., Ford Motor Co., Cleveland. He assumes the post formerly occupied by **F. X. Bujold,** who has been reassigned to special duties within the division. **E. E. Harkess,** former foundry production manager, is now foundry plant manager, the position previously held by Jeter.

In his new post, Jeter will have responsibility for the Cleveland foundry, the Dearborn Iron Foundry, Dearborn, Mich., the Dearborn Specialty. Foundry and the Sheffield, Ala. aluminum foundry.

Verne Pulsifer . . . is now technical administrator, Fansteel Metallurgical Corp., North Chicago, Ill. He was formerly on the staff of Armour Research Foundation, Chicago.

L. A. Dunn . . . is general manager, Buck Iron Co., Buck, Pa. He was general manager of the General Electric Co. foundry in Erie, Pa. for 25 years.

L. Russell Munch . . . is sales engineer in the Ohio area for Frederic B. Stevens, Inc., Detroit. He was formerly with Ohio Decorative Co., Wapakoneta, Ohio.

Charles Menzer . . . has joined Superior Bronze Castings Co., Carlstadt, N. J. He was formerly works manager, Alloy Steel Castings Co., South Hampton, Pa.

Frank Mattson . . . formerly sales representative, Hickman, Williams & Co., is now resident manager with headquarters in Philadelphia.

James M. Planten . . . is now vice-president, Foundry Design Co., St. Louis, an affiliate of Sorbo-Mat Process Engineers. He was formerly vice-president, Lester B. Knight & Associates, Chicago.

James E. Martin . . . has been named Cleveland district manager for Pangborn Corp., Hagerstown, Md. Martin, who has been with Pangborn for 14 years, succeeds **Robert E. Donnelly** who retired after 30 years service.

Charles E. Robinson . . . formerly with Robinson & Robinson is now vice-president, Derby Co., Pittsburgh, Pa. He is a member of the Pittsburgh Chapter.

Clarence L. Bowman . . . formerly a foundry consultant is now manager of quality control, Golden Foundry Co., Columbus, Ind. He is a member of the Central Indiana Chapter.

Allen Draper . . . formerly secretary and general manager, Draper-Weatherly Co., is now president, Industrial Supply & Equipment Co., Anniston, Ala. He is a member of the Birmingham Chapter.

John Hood . . . formerly with Kaiser Steel Corp. is now associated with Atlas Foundry & Mfg. Co., Richmond, Calif. He is a member of the Northern California Chapter.

Vernon C. Lewis . . . formerly with Hamilton Foundry Co., Hamilton, Ohio, is now with National Cash Register Co., Dayton, Ohio. He is a member of the Cincinnati Chapter.

W. E. Miemackl . . . . has been elected a director of Minneapolis Electric Steel Castings Co., Minneapolis. He will continue in his duties as vice-president and sales manager.

Albert W. Lang . . . is now foundry superintendent, Universal-Rundle Corp., Camden, N. J. He was previously foundry metallurgist.

L. D. Alpert . . . formerly general manager of the eastern department of Federated Metals Div., American Smelting & Refining Co., is now general manager of division's Whiting, Ind., plant. **P. H. Jackson,** formerly vice-president and general manager, Federated Metals Canada, Ltd., succeeds Alpert. **G. F. Norman,** manager of Federated Canada's Montreal plant, replaces Jackson; **H. Trihey,** who has been the plant's sales manager, succeeds Norman.

Reginald B. Beam . . . for 33 years with Joseph Dixon Crucible Co., Jersey City, N.J., is now industrial district manager with headquarters in Chicago succeeding **Emory Bleam** who retired.

Harold R. Fisher . . . formerly metallurgist with Lynchburg Foundry Co., Lynchburg, Va., is now metallurgist, Grand Rapids Foundry, Grand Rapids, Mich. He is a member of the Western Michigan Chapter.

William R. Butler . . . has been appointed manager, castings sales for Aluminum Co. of America. Butler, in charge of die casting sales since 1955, will be responsible for the sale of sand, die, permanent mold and plaster castings. This is the first time sales of all the company's foundry products have been grouped in one department.

Clarence A. Gehrman . . . is now manager, flask division, Risney Foundry Equipment Co., Hales Corner, Wis. He formerly served 30 years with Sterling National Industries, Milwaukee, latterly as sales manager. He will cover the Wisconsin and Minnesota territory.

Paul A. Schroeder . . . formerly with Foundry Specialties Mfg. Co., Chicago, is now foundry superintendent, Kensington Steel Co., Chicago.

C. E. Fausel . . . formerly manufacturing superintendent, Central Foundry Div., GMC, Danville, Ill., is now superintendent, Chicago Foundry Co., Chicago.

Larson E. Wile . . . formerly with Pangborn Corp., is now project engineer, Lynchburg Foundry Co., Lynchburg, Va.

Louis V. Abrams . . . has been named administrative assistant to the president, Pangborn Corp., Hagerstown, Md. He had served as plant manager for the Kelsey-Hayes Alloy Aircraft Wing Plant in Clark, N. J., and recently was employed in management consulting work.

Ralph W. Bailey . . . has been named assistant general sales manager, Federated Metals Div., American Smelting & Refining Co. Bailey joined the company in 1945 and retains his position as sales manager of Continuous-Cast Products Dept.

Thomas M. Bohen . . . has retired from active service with Whitehead Metals, Inc., an affiliate of International Nickel Co. He was the first employee of Whitehead Metals formed in 1914 and will continue as honorary chairman and honorary director.

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chapter meetings

Continued from page 128

neapolis . . J. H. Schaum, AFS, *"What's New in Metalcasting."*

Utah . . Sept. 21 . . W. D. Chadwick, Manley Sand Co., *"Sand Segregation."*

Washington . . Sept. 17 . . Engineers' Club, Seattle . . W. D. Chadwick, Manley Sand Co., *"Sand Segregation."*

Wisconsin . . Sept. 11 . . Schroeder Hotel, Milwaukee . . *Gray Iron Group*: J. E. Fitzwater, International Harvester Co., *"Salvage Welding in Gray Iron"; Steel Group*: Prof. R. A. Flinn, University of Michigan, *"Gating & Risering"; Malleable Group*: J. H. Lansing, Consultant, *"Malleable Practice"; Non-Ferrous Group*: G. L. Armstrong, U. S. Reduction Co., *"Metallurgy of Aluminum Allos"; Pattern Group*: J. Wiss, Permaflex Mold Co., *"Flexible Rubber for Pattern Shop Use."*

OCTOBER

Birmingham District . . Oct. 9 . . Thomas Jefferson Hotel, Birmingham, Ala. . . S. F. Carter, American Cast Iron Pipe Co., *"Practical Tips on Cupola Operation."*

Central Indiana . . Oct. 5 . . Turner's Athenaeum, Indianapolis.

Central New York . . *See Empire State Regional Foundry Conference.*

Central Ohio . . *See Ohio Regional Foundry Conference.*

Chesapeake . . Oct. 23 . . Engineers' Club, Baltimore, Md. . . J. D. Allen, Jr., Federated Metals Div., American Smelting & Refining Co., *"New Developments in Non-Ferrous Cast Metals."*

Chicago . . Oct. 5 . . Chicago Bar Association, Chicago.

Cincinnati District . . Oct. 12 . . Eaton Manor, Hamilton, Ohio . . *"Vertical Gating" Film and Panel Discussion.*

Corn Belt . . Oct. 16 . . Cotner Terrace Supper Club, Lincoln, Neb. . . J. Albanese, Acme Resin Corp., *"Resin Binders, Shell & Core Molding Techniques."*

Empire State Regional Foundry Conference . . Oct. 1-2 . . Drumlin's Country Club, Syracuse, N. Y.

Metropolitan . . Oct. 5 . . Essex House Hotel, Newark, N. J.

Michiana . . Oct. 12 . . Felberg's, St. Joseph, Mich. . . R. L. Gilmore, Superior

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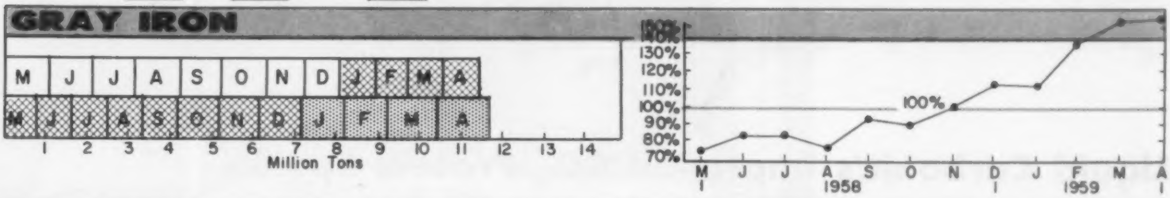
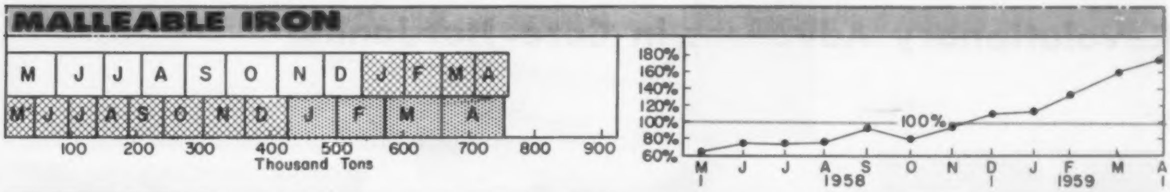
how's business . . .

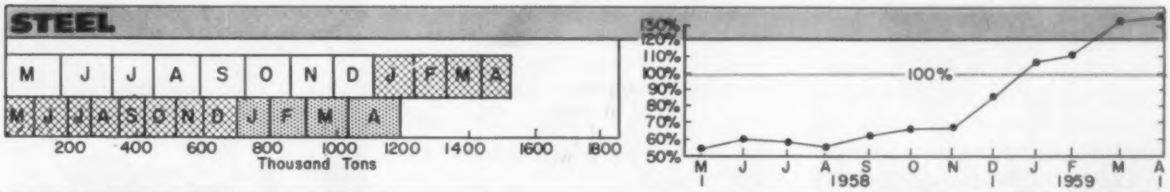
The right-hand set of graphs demonstrate the steady climb of business during the last half of 1958 and continuing into 1959. Shipments for each of the last 12 months are compared with the corresponding month a year previously and the ratio converted to per cent. For example, gray iron shipments were 1,112,096 tons in May, 1957, and 820,054 tons in May, 1958 – about 74 per cent of the 1957 rate. So the curve starts at 74 per cent for May, 1958, and climbs to 154 per cent for April, 1959, when shipments of 1,245,702 tons exceeded by far the 806,720 tons shipped in April, 1958.

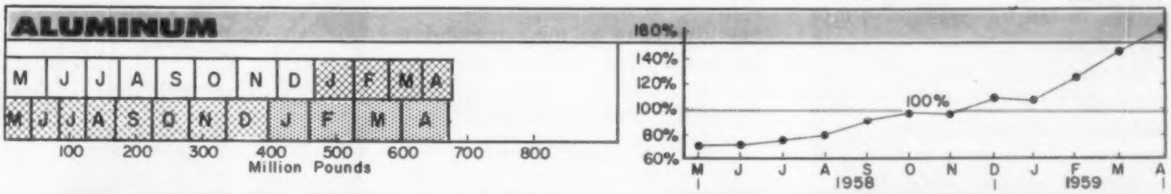
Business in the metalcasting industry is on the upswing. By using statistics provided by the Bureau of Census, Department of Commerce, Modern Castings has prepared this special comparison of month-to-month metalcasting shipments for the years 1957, '58 and '59. On the left, horizontal bar charts give a direct comparison of each month for the two year period May 1957 through April 1959 and the accumulative total for the two years.

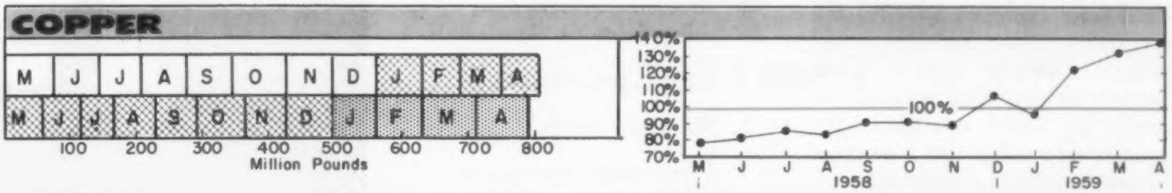
KEY -- 1957 1958 1959

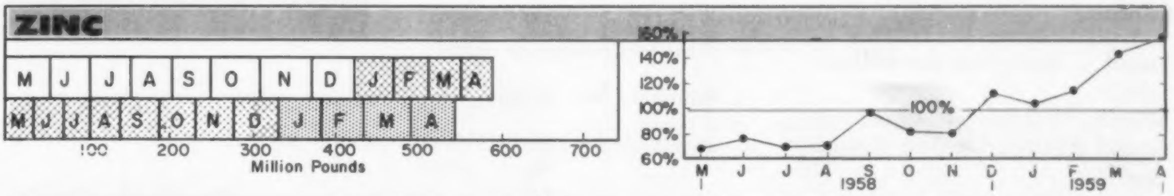


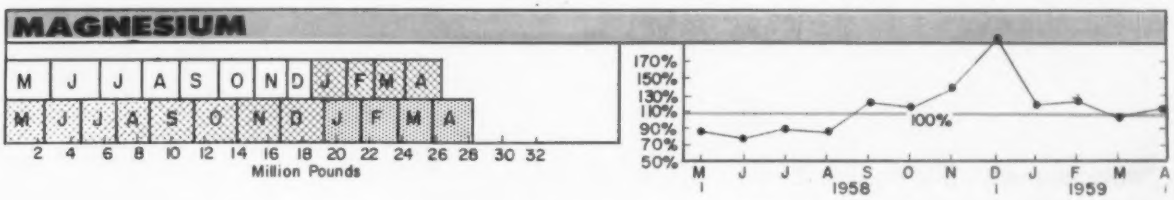












"Bakeless" cores and molds in 20 seconds

Liquid Carbonic's Improved CO_2 Process Sparks Revolutionary Advances in Core-Hardening

Requests for "we-need-it-tomorrow" deliveries seem to cram a foreman's order pad every day. Until now, immediate delivery has been a source of concern to the foundry industry because of lengthy baking and drying procedures.

Because of this, more and more foundries are adopting the bakeless CO_2 core-hardening process. Intricate cores can be made with CO_2 in a matter of seconds; completely finished cores (rammed, gas-hardened and removed) are produced in less than three minutes. Thus, CO_2 has become the propelling ingredient in production boosts throughout the country—so much so that it promises to soon become *the* method of core-hardening.

Speed . . . And Other Advantages

Actually, it's simply a matter of supply and demand: the great demand today is for speed—therefore, CO_2. It doesn't just end there . . . the CO_2 process makes other core-making techniques old-fashioned. For example:

1. Eliminates baking ovens and core dryers
2. Better dimensional stability
3. Smoother finish on castings
4. Excellent shakeout and collapsibility
5. Reduces production costs
6. Minimizes rejects
7. Eliminates excessive core inventory
8. Expedites emergency orders
9. Simplifies core design
10. Adaptable for automation

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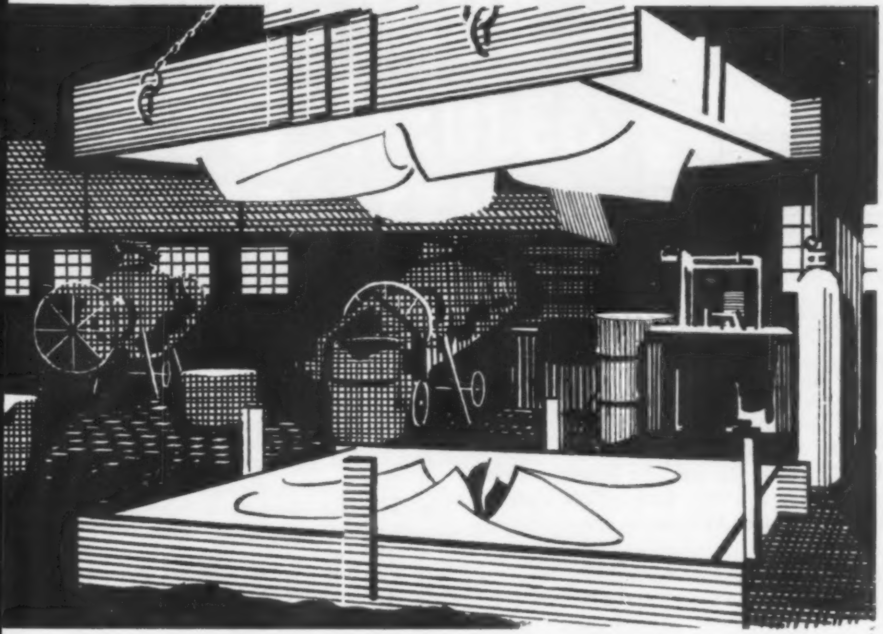

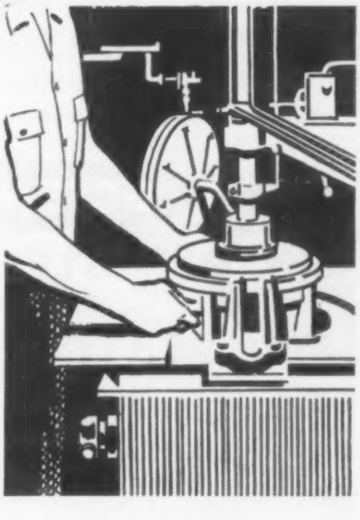

CO_2 Ideal for Mold-Hardening, Too
In addition to these advantages, many foundries have discovered that CO_2 is just as beneficial in mold-making as it is in core-hardening. Dry sand molds sometimes require baking at 300° to 400° F. for periods up to 75 hours; the CO_2 process can do the same job at time-savings up to 95%. CO_2 molding also can save as much as 90% in machine-shop costs, cuts labor requirements, and works equally well on both large- and small-size molds.

Although CO_2 is a relative newcomer to core-making, many improvements have already been made since it was first introduced. A trained staff of Liquid Carbonic engineers have been working for years to improve the CO_2 process. The combination of research, development, and daily shop practice, has brought the CO_2 process up to today's high standards, making it the preferred method of core- and mold-hardening in today's foresighted foundries. Call your Liquid Carbonic representative today and have him show you how CO_2 can improve your production!

How much do you know about sand reclaiming? For an authoritative, educational article, send in the coupon below.

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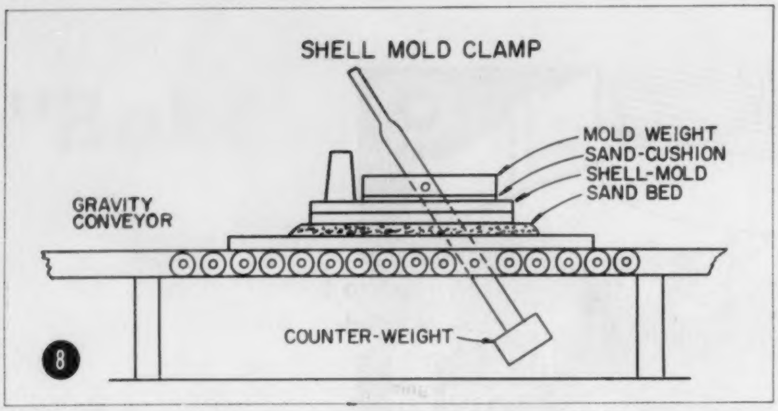

Mold clamp mechanically applies proper weight to shell.

primer on shell molding

Continued from page 50

most shells through a core with sixteen holes (3/16 in. diameter).

Horizontal pouring of shell molds offers the most convenient method for most foundry operators. Vertical pouring requires space and larger capital outlay for special installations and conveyor systems.

Horizontal pouring also restricts the number of cavities per mold because of the additional area required for gluing the shells in the bonding machine.

Pouring of shells horizontally dictates the use of a longer pouring spout on the ladle. This delivers the metal as close to the sprue cup as possible, thus minimizing ferro static pressure, often the cause of run-outs and warping through cracked shells and excessive finning across the parting line. Figure 7 illustrates the recommended design of a pouring ladle to allow the pourer greater facility in delivering clean metal to the pouring cup.

Weighting-down shell molds is often required when a casting having a broad horizontal area subjects the cope shell to a high momentum lift. This operation can be facilitated by using a mold weight with a simple mechanical aid, as depicted in Fig. 8. The danger of shell cracking common to manual weight depositing is eliminated.

In summation the author hopes this article will provide some help to the foundrymen that regard shell molding as a process that is here to stay as a permanent fixture in foundry technology. In many ways it produces a saleable casting.

LET YOUR AFS EMBLEM BE SEEN

- **Buy any of the following jewelry for yourself.**
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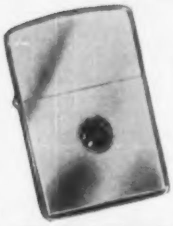
Each of the Rhodium-plated articles has a black and silver insignia, burnished to gleaming highlights . . . offered at cost prices to AFS members . . . a quality addition to your dress or sports outfit . . . so right to demonstrate your affiliation with AFS, international technical society of the metal castings field.



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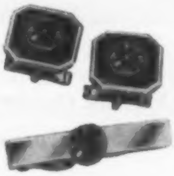
For unmatched dependability, the ever-popular Zippo . . . characterized and made. even more attractive with the AFS insignia, boxed **$4.00**

MONEY CLIP

For the man who safeguards his currency with a clip, here is an easy-to-use clip . . . exceptionally sturdy "grip"......**$1.50**

SERVICE PINS

The Society recognizes 25, 30, 35, 40 and 50 years of continuous membership in AFS with service pins. Just send your name and record of employment in the castings field. .... **Gratis**



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Keynote to masculine fashion and good grooming is this combination cuff links and tie bar set, gift box..........**$3.50** Also sold separately: Links, **$2.50**; Tie Bar, **$1.00.**

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Miniature size to add just the right sparkle to your lapel . . . to show you are proud to be known as an AFS Member . . **$1.00**

KEY CHAIN

As sturdy as it is beautiful. Double-clasp catch holds keys on slip-easy ring. Attached to attractive medallian with 2½-inch link chain **$1.50**

STUDENT KEY

A perfect recognition of the student's acceptance to membership in a technical Society. **$1.25**

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ABC

A DEPENDABLE SOURCE of SUPPLY

Year after year, more and more foundries in over 30 states have looked to ABC as their source of supply for quality coke.

That's because foundries know that:

ABC — one of the nation's largest independent merchant coke producers — has adequate capacity to serve their needs at all times and under all conditions. Annual productive capacity is 875,000 tons.

ABC has rigidly maintained the high quality of its coke for 39 years.

ABC has earned an outstanding reputation for meeting the widely varying requirements of its customers in periods of peak demand.

ABC has no affiliations that have first call on its production. Its customers come *first.*

ABC's modern plant in the Birmingham District is strategically located to give prompt service.

ABC has continually improved the quality of its coke through research and constant betterment of its facilities and equipment.

ABC coke is produced in two distinct types —STANDARD and MALLEABLE —to meet the exacting requirements of any cupola operation. Both grades are regularly cupola-tested at our ovens for carbon control and highest performance.

ABC

When you make ABC your source of supply, you will establish a connection of lasting satisfaction. Your inquiries are invited.

ALABAMA BY-PRODUCTS CORPORATION

General Sales Office: First National Building, Birmingham, Alabama

Sales Agents: [illegible] FOUNDRY SAND COMPANY, Detroit; ST. LOUIS COKE & FOUNDRY SUPPLY CO., St. Louis; THE [illegible] AND ORE COMPANY, Cincinnati; KERCHNER, MARSHALL AND COMPANY, Pittsburgh; [illegible] & COMPANY, LTD., San Francisco; ATWILL COKE AND COAL COMPANY, Chicago.

Circle No. 179, Page 157-158

Build an idea-file for improvement and profit. The post-free cards on the last page will bring more information . . .

for the asking

Contact wheels . . . catalog No. CWIR-659 describes facts needed for selection and application of rubber wheels. *Chicago Rubber Co.*
For Your Copy, Circle No. 61, Page 157-158

Bentonite . . . western and southern, covered in brochure listing specifications and advantages. *Magnet Cove Barium Corp. Ltd.*
For Your Copy, Circle No. 62, Page 157-158

Fire brick . . . designed for blast furnace use is subject of 4-p brochure Vol. 2 No. 2. Includes test data. *North American Refractories Co.*
For Your Copy, Circle No. 63, Page 157-158

Why preventive maintenance? . . . pamphlet discusses facts of company's new program. *Beardsley & Piper Div. Pettibone Mulliken Corp.*
For Your Copy, Circle No. 64, Page 157-158

Foundry coke . . . bulletin offers information on chemical analysis, high strength, close sizing, and research and development. *Hickman, Williams & Co.*
For Your Copy, Circle No. 65, Page 157-158

Sand muller . . . reportedly saves up to 30 per cent in binder. Fully detailed in brochure No. WL 9227. *Carver Foundry Products.*
For Your Copy, Circle No. 66, Page 157-158

Charging systems . . . bulletin No. FY-179 portrays four types in action. *Whiting Corp.*
For Your Copy, Circle No. 67, Page 157-158

Automatic loading ramp . . . self-contained, can be either recessed into the loading dock floor or set on four legs in front of dock. Use the Reader Service card, last page, for details. *American Dockbridge, Inc.*
For Your Copy, Circle No. 68, Page 157-158

Tape recordings . . . of technical talks on many facets of the metal castings industry are available from AFS. Includes discussions on cupola operation, air pollution control, self-curing oil binders, producing quality castings and many more. *American Foundrymen's Society.*
For Your Copy, Circle No. 69, Page 157-158

Used instruments . . . designed for specialized engineering and testing purposes have been used for demonstration or special purposes, according to manufacturer. Request price list by using circle number, last page. *Brush Instruments.*
For Your Copy, Circle No. 70, Page 157-158

Ceramic gating . . . catalog covers components for all standard cores, splash cores, elbows and tubes. For more information circle number on Reader Service card. *Universal Clay Products Co.*
For Your Copy, Circle No. 71, Page 157-158

Core blowing . . . and mold blowing machines described in 32-p booklet listing features and applications. *Beardsley & Piper Div., Pettibone Mulliken Corp.*
For Your Copy, Circle No. 72, Page 157-158

Investment casting . . . design guide explains process, lists comparison of costs with other casting processes and offers many line drawings of design do's and don'ts. *Picco Industries.*
For Your Copy, Circle No. 73, Page 157-158

Pricing . . . arithmetic for small business managers discussed in government bulletin No. 100. *Small Business Administration.*
For Your Copy, Circle No. 74, Page 157-158

Precision temperature . . . measurement pyrometers, optical, micro-optical, radiation, immersion, surface and indicating discussed in catalog No. 175. *Pyrometer Instrument Co.*
For Your Copy, Circle No. 75, Page 157-158

Safety chart . . . illustrating safe handling of lever-operated hoists offered free for the asking. *Manning, Maxwell & Moore, Inc.*
For Your Copy, Circle No. 76, Page 157-158

Plant operations . . . delineated for foundry casting aluminum, bronze and copper base alloys. Many pictures show all aspects of company's operations. *Oberdorfer Foundries, Inc.*
For Your Copy, Circle No. 77, Page 157-158

Time-zone map . . . depicting standard time zones of the United States and Canada offered. *Ohio Seamless Tube Div. Copperweld Steel Co.*
For Your Copy, Circle No. 78, Page 157-158

Stainless steel . . . machining data bulletin includes information regarding 188 compositions of stainless steel relative to feeds, machining speeds and grades of carbide cutting edges best suited for roughing, semi-finishing and fine finishing. *Kennametal Inc.*
For Your Copy, Circle No. 79, Page 157-158

Foundry sand . . . brochure details processing facilities and operations for 24 grades of foundry sand. Wedron Silica Co.
For Your Copy, Circle No. 80, Page 157-158

Molybdenum . . . use in abrasive-resistant materials detailed in brochure covering gouging, grinding and scratching; and proper selection of material for particular types and conditions of wear. *Climax Molybdenum Co.*
For Your Copy, Circle No. 81, Page 157-158

Moldability . . . effects achieved with western bentonite discussed in leaflet. *American Colloid Co.*
For Your Copy, Circle No. 82, Page 157-158

Barrel finishing . . . equipment featuring 11 specialized machines described in new, illustrated brochure. Yours for the asking. *Almco, Queen Products Div., King-Seeley Corp.*
For Your Copy, Circle No. 83, Page 157-158

Hinged pan conveyors . . . and their application to foundries covered in 4-p bulletin. *Anchor Steel & Conveyor Co.*
For Your Copy, Circle No. 84, Page 157-158

Wood pallets . . . minimum standard specifications listed in leaflet. Contains recommended minimum specifications for permanent types of wooden pallets made from Douglas Fir, Hemlock or Larch species of lumber. *National Wooden Pallet Manufacturers Association.*
For Your Copy, Circle No. 85, Page 157-158

Titanium . . . technical information for engineers, metallurgists and designers available in booklet. *Harvey Aluminum.*
For Your Copy, Circle No. 86, Page 157-158

Shell molding . . . produced for national television program, film provides introduction to shell molding techniques. Black and white, 16 mm, sound, free. *Cooper Alloy Foundry Co.*
For Your Copy, Circle No. 87, Page 157-158

Grinding and buffing . . . machinery catalog contains descriptive information, illustrations and specifications. *Cincinnati Electrical Tool Co.*
For Your Copy, Circle No. 88, Page 157-158

Oil-free compressors . . . presented in illustrated brochure including design specifications and applications. *Joy Mfg. Co.*
For Your Copy, Circle No. 89, Page 157-158

Infra-red elements . . . for industrial processing applications specified and applications presented in folder. *Ampere Industries.*
For Your Copy, Circle No. 90, Page 157-158

Core wire cutters . . . and wire straighteners detailed in folder. Designed to fasten to benches. *Beardsley & Piper Div., Pettibone Mulliken Corp.*
For Your Copy, Circle No. 91, Page 157-158

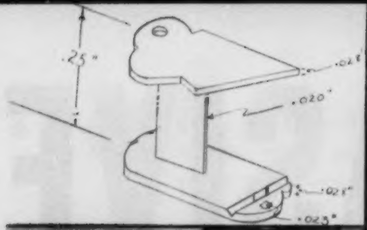
Vacuum melting techniques . . . and high-temperature vacuum-melted alloys covered in brochure. *General Electric Co., Metallurgical Products Dept.*
For Your Copy, Circle No. 92, Page 157-158

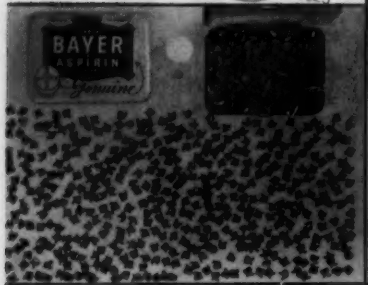
Answers for students . . . about the foundry industry, its products and career opportunities comprise booklet available for distribution to student groups. *Foundry Educational Foundation.*
For Your Copy, Circle No. 93, Page 157-158

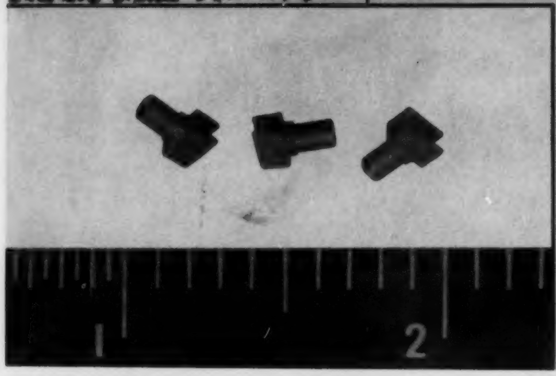
Brass and bronze . . . specification index composed of rotating cardboard disk which shows all physical requirements and chemical composition of A. S. T. M.,

Continued on page 144

Circle No. 181, Page 157-158







World's Smallest Castings

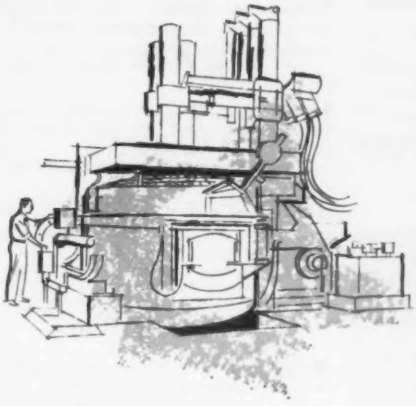
■ In answer to Modern Casting's challenge to come forth and make claim to the title of "World's Smallest Casting," three contenders have entered the ring.

■ Diagrammed at the upper left is an entry made by Ferro Cast, Div. of J. B. Rea Co., Santa Monica, Calif. This investment cast frame and core for a miniature relay measures 0.25 in. long and the core section has the remarkable dimension of only 0.020 in. thick. Cast in a high silicon steel with the aid of vacuum metallurgy the parts were produced at a substantially reduced cost.

■ The sub-miniature two-bladed vanes shown in the center pic are so small that 436 castings can be packed in an aspirin box. Proud producer of these tiniest of tiny castings is Precision Metalsmiths, Inc., Cleveland. Cast in 347 stainless steel, 275 beryllium copper and 356 aluminum each part measures 0.125 in. x 0.125 in.

■ And then we have in the lower left hand corner the third fly-weight challenger sponsored by Casting Engineers, Inc., Chicago. This diminutive part of the needle holder on a high fidelity pick-up arm is cast in 356 aluminum. The walls are very thin—less than 0.025 in.—and a 0.050 in. hole is cast through the part. Approximately 2000 castings comprise a pound so the customer's semi-annual shipments can be mailed in an ordinary business envelope.

■ You be the judge of the winner. It sure looks like a photo-finish! Our metalcasting industry can well be proud of the pace these foundries are setting in this current period of exploding technology.—Editor



Lectromelt ships 77% of furnace spare-part orders from stock

When you need replacement parts on a Lectromelt electric furnace, you'll find we are as interested in speed as you. Therefore, we've set up a separate service department to handle sales, check orders against original blueprints to insure accuracy, and maintain a complete spare parts inventory.

Routine orders are in and out in a few days; rush orders in a few hours. A very large stock is maintained so that *over 77% of current orders* are filled right off the shelf.

Lectromelt service is geared to help you operate efficiently for years to come. Thus, if you're planning new capacity, you'll find it wise to contact Lectromelt now. Lectromelt Furnace Division, McGraw-Edison Company, 316 32nd Street, Pittsburgh 30, Pennsylvania.

FOR THE MOST EFFICIENT MELTING Lectromelt® McGRAW-EDISON

CANADA: Wild-Barfield Electric Furnaces, Ltd., Toronto . . . ITALY: Forni Stein, Genova . . . ENGLAND: G.W.B. Furnaces Limited, Dudley, Worcs. . . . GERMANY: Demag-Elektrometallurgie, GmbH, Duisburg . . . SPAIN: General Electrica Espanola, Bilboa . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Stein & Roubaix, Bressoux-Liege . . . JAPAN: Daido Steel Co., Ltd., Nagoya

Circle No. 183, Page 157-158

for the asking

Continued from page 140

Federal, Military and S. A. E. specification numbers. Line up specification number, and data shows up in "windows" in disk. *Roessing Bronze Co.*
For Your Copy, Circle No. 94, Page 157-158

Barrel cleaning . . . unit with 72-cu ft barrel completely described and applications illustrated in 16-p bulletin No. 705. *Pangborn Corp.*
For Your Copy, Circle No. 95, Page 157-158

X-rays . . . and gamma rays for nondestructive testing and inspection of castings discussed in 12-p booklet. Claimed to answer questions most frequently asked about these methods. *Picker X-Ray Corp.*
For Your Copy, Circle No. 96, Page 157-158

Sling chain handbook . . . 32 pp, includes information regarding ordering, care, use and inspection of company's line. Contains diagrams, charts and tables on standard and special styles. *Columbus McKinnon Chain Corp.*
For Your Copy, Circle No. 97, Page 157-158

Management aids . . . Five reports which, according to company, can be used to effectively manage any manufacturing organization. Brochure discusses reports and method of use. *Royal McBee Corp., Data Processing Div.*
For Your Copy, Circle No. 98, Page 157-158

Industrial truck batteries . . . said to deliver 44 per cent more power than conventional batteries, described in brochure. *Exide Industrial Div., Electric Storage Battery Co.*
For Your Copy, Circle No. 99, Page 157-158

Portable elevator . . . for vertical material handling; applications illustrated in 18-p booklet. *Association of Lift Truck and Portable Elevator Mfg.*
For Your Copy, Circle No. 100, Page 157-158

Fog nozzles . . . said to produce extremely fine fog covered in data sheet. *Bete Fog Nozzle, Inc.*
For Your Copy, Circle No. 101, Page 157-158

Pallet rack . . . is adjustable by lift truck. Free brochure shows you how it's done. *Hartman Metal Fabricators, Inc.*
For Your Copy, Circle No. 102, Page 157-158

Electric lift truck . . . stand-up operated, detailed in brochure. *Heifred Corp.*
For Your Copy, Circle No. 103, Page 157-158

Midget cylinders . . . feature pressure of 200 psi (air) and 750, 2000 psi hydraulic. Use circle number below for literature. *Control Line Equipment.*
For Your Copy, Circle No. 104, Page 157-158

Band-saw blade . . . coil stock in 100 and 400-ft lengths discussed in folder. *Boice-Crane Co.*
For Your Copy, Circle No. 105, Page 157-158

Shakeout table . . . and screens for small plants covered in brochure. *Somil Equipment & Supply Co.*
For Your Copy, Circle No. 106, Page 157-158

Chipping hammer . . . with shock absorber and power-controlled cut described in brochure. *Ingersoll-Rand Co.*
For Your Copy, Circle No. 107, Page 157-158

Respirator . . . for protection against excessive heat, shown in leaflet. *American Optical Co.*
For Your Copy, Circle No. 108, Page 157-158

High temperature furnace . . . electric, for operation to 3100 F discussed in brochure. *K. H. Huppert Co.*
For Your Copy, Circle No. 109, Page 157-158

Cleaner and degreaser . . . designed for all types of industrial cleaning with one compound. Use circle number for information. *Harco Chemical Co.*
For Your Copy, Circle No. 110, Page 157-158

Enlargement control . . . for in-plant photography departments detailed in brochure. *Ideax Corp.*
For Your Copy, Circle No. 111, Page 157-158

Heavy duty oiler . . . readily attached to standard quart oil can is described in data sheet. *Buerkens Corp.*
For Your Copy, Circle No. 112, Page 157-158

Air control valve . . . for lifts, hoists, etc., presented in leaflet. *Jordan Industrial Sales Div., OPW Corp.*
For Your Copy, Circle No. 113, Page 157-158

training films

■ **The following list of motion pictures and film strips will prove useful in educating your personnel to better perform their jobs. Circle the appropriate number on the Reader Service Card, last page, for complete information regarding these films. Items indicate whether films are available free of charge, by rental or by purchase only.**

The Green Drum . . . covers complete operations of ferroalloy company from mining of ore to shipment of finished products. Color, 16mm, sound, 23 min., free. *Vanadium Corp. of America.*
For Your Copy, Circle No. 114, Page 157-158

A Product of the Imagination . . . traces history of aluminum from discovery through modern processes, plants and products. Color, sound, 16 and 35 mm, 26 min., free. *Aluminum Co. of America.*
For Your Copy, Circle No. 115, Page 157-158

What's in a Name? . . . is a centennial company film depicting development from one-room shop to world-wide operations. Color, sound, 17 min., free. *Gardner-Denver Co.*
For Your Copy, Circle No. 116, Page 157-158

Epoxy tooling resins . . . film features shop applications. Show step-by-step laminating and casting of foundry patterns, among other operations. Color, sound, 16 mm, 36 min., free. *United States Gypsum Co.*
For Your Copy, Circle No. 117, Page 157-158

Reusable Wooden Containers . . . said to show how containers result in lower production and distribution costs. Color,

Continued on page 146

chapter meetings

Continued from page 132

Steel & Malleable Castings Co., *"Casting Design for Survival."*

Michigan Regional Foundry Conference . . Oct. 8-9 . . Pantilind Hotel, Grand Rapids, Mich.

Mid-South . . Oct. 9 . . Claridge Hotel, Memphis, Tenn.

New England Regional Foundry Conference . . Oct. 16-17 . . Massachusetts Institute of Technology, Cambridge, Mass.

Northeastern Ohio . . Oct. 8 . . Tudor Arms Hotel, Cleveland . . H. F. Bishop, Exomet, Inc., *"Exothermic & Insulating Materials."*

Northwest Regional Foundry Conference . . Oct. 2-3 . . Benjamin Franklin Hotel, Seattle.

Ohio Regional Foundry Conference . . Oct. 22-23 . . Deshler-Hilton Hotel, Columbus, Ohio.

Oregon . . *See Northwest Regional Foundry Conference.*

Philadelphia . . Oct. 9 . . Engineers' Club, Philadelphia . . Dr. J. C. Elgin, Princeton University, *"Education & Industry Today."*

Pittsburgh . . Oct. 19 . . Webster Hall Hotel, Pittsburgh, Pa. . . A. A. Evans, International Harvester Co., *"Quality Control in the Foundry."*

Purdue Metals Casting Conference . . Oct. 29-30 . . Purdue University, West Lafayette, Ind.

Saginaw Valley . . Oct. 1 . . Fischer's Hotel, Frankenmuth, Mich. . . C. C. Sigerfoos, Michigan State University, *"European Foundry Experience."*

St. Louis District . . Oct. 8 . . Edmond's Restaurant, St. Louis . . C. E. Drury, Central Foundry Div., GMC, *"Pouring Effect on Scrap."*

Southern California . . Oct. 9. . . Kaiser Steel Co., Fontana, Calif. . . *Plant Visitation.*

Texas . . Oct. 16 . . Menger Hotel, San Antonio, Texas.

Toledo . . Oct. 7 . . Heatherdowns Country Club, Toledo, Ohio.

Twin City . . Oct. 28 . . Calhoun Beach Hotel, Minneapolis . . G. C. Schelley, Do-All Co., *"Story of the Cutting Edge."*

Washington . . *See Northwest Regional Foundry Conference.*

Western New York . . *See Empire State Regional Foundry Conference.*

for the asking

Continued from page 144

sound, 16 mm, 20 min., free. *National Wooden Box Association.*
For Your Copy, Circle No. 118, Page 157-158

free reprints

■ **The following reprints of feature articles which appeared in MODERN CASTINGS are available to you free of charge. Use the Reader Service card, last page.**

Foundry training . . . course sponsored by the AFS Training and Research Institute is valuated from the students point of view in article offered to you in reprint form.
For Your Copy, Circle No. 119, Page 157-158

Ductile iron technology . . . reprint covers important facts you should know before attempting to produce this metal. *American Foundrymen's Society.*
For Your Copy, Circle No. 120, Page 157-158

European foundries . . . over 80 of them, were toured by author of free reprint from MODERN CASTINGS presenting many ideas you may find useful. *American Foundrymen's Society.*
For Your Copy, Circle No. 121, Page 157-158

European foundries . . . and ideas gained from touring them discussed in reprint of article published in MODERN CASTINGS. *American Foundrymen's Society.*
For Your Copy, Circle No. 122, Page 157-158

Size of scrap . . . effects tapping temperature of the cupola. A report on this subject, reprinted from MODERN CASTINGS, is yours for the asking. *American Foundrymen's Society.*
For Your Copy, Circle No. 123, Page 157-158

obituaries

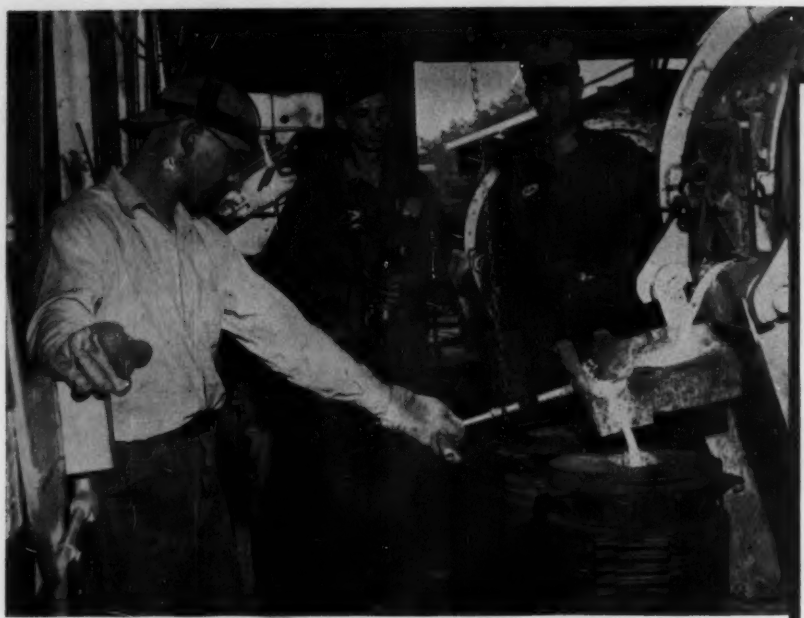
John K. Schubert, 60, manager of shop operations, iron foundry, General Electric Co., Schenectady, N.Y., died June 29 at the age of 60. He was a member of the AFS Eastern New York Chapter.

Alex B. Hawes, 70, salesman for Ranson & Orr, died June 29 at Ft. Thomas, Ky. He had been associated with the foundry business since 1908.

W. T. Gallmeyer, president, Gallmeyer & Livingston Co., Grand Rapids, Mich., died in July.

Harry C. Weiskittel, Jr., 61, president, Harry Weiskittel Co., Inc., Baltimore, Md., died Aug. 1 at his home.

Circle No. 186, Page 157-158



RALPH E. ANDERSON, 28
Graduate Illinois Institute of Techno'ozy. Economics; Major in Math. Graduate work in Math., Michigan State U. Quality Control Engineer—Statistician. Formerly with Western Elecric Co., Chicago.

FRANCIS H. HUTCHINS, 32
B.S. Metallurgical Engineering, University of Michigan 1950. Formerly, operating Metallurgist and General Foreman Chevrolet Gray Iron Division, G.M.C. Presently Plant Metallurgist, Engineered Castings Inc.

EGGHEADS

IN THE FOUNDRY?

Not many years ago, "eggheads" like mathematicians and statistical analysis engineers were strangers in foundries. Today, however, the basic foundry industry has evolved from an artisan's craft to a highly scientific, technological field. It requires engineering talent in many areas such as electrical, mechanical, metallurgical, and statistical engineering.

Engineering Castings Inc., Marshall, Mich., provides an excellent example of the technical and scientific nature of the modern foundry industry and the high degree of knowledge required of its technical personnel. ECI sometimes is referred to as the "prescription-counter" foundry because of the number and complexity of the alloys it runs to produce a wide range of quality castings for engineering applications in many industries.

At Engineering Castings, castings are produced, under strict process and quality control methods, to exacting metallurgical specifications, physical standards, and dimensional tolerances. Some castings even are produced to a metallographic go, no-go requirement. Controlled microstructure must be held within two limits metallographically. Nature, size, and distribution of the graphite and carbides and the matrix itself are held to tight specifications.

Two of the younger engineers on whom Engineering Castings relies for the high degree of specialized knowledge necessary to meet these quality standards are pictured here.

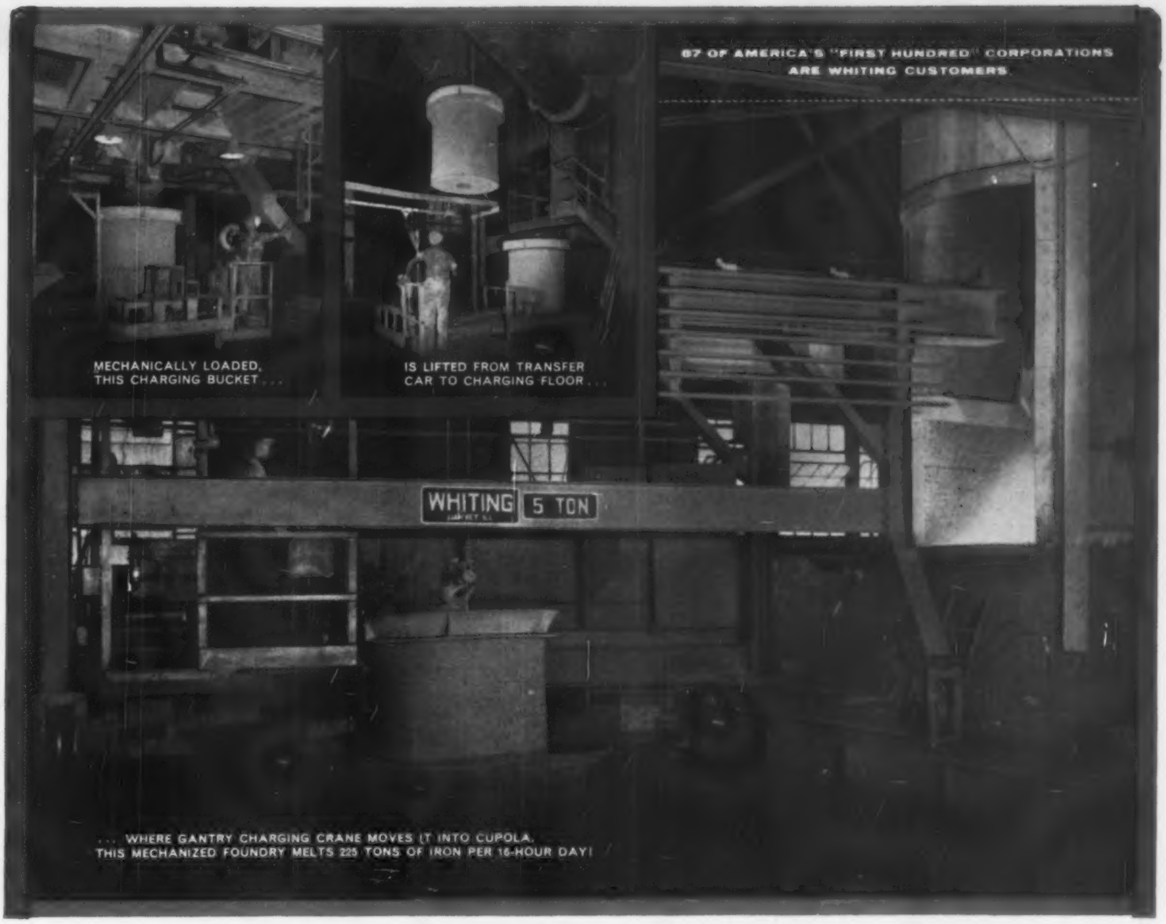
The Foundry Educational Foundation—created by and for the foundry industry—provides the principal source of critically needed engineering and scientific personnel. Availability of an adequate supply of technical manpower depends on your support. You can become a partner in engineering progress in cast metals by participating in the Foundry Educational Foundation.

Foundry Educational Foundation

1138 TERMINAL TOWER BUILDING • CLEVELAND 13, OHIO

The Foundry Educational Foundation does not pay for this advertising. This advertisement has been prepared and the space contributed by FOUNDRY magazine in support of FEF's constructive program for foundry industry progress through education.

Circle No. 187, Page 157-158



At American Standard... Charging time cut one-third!

New mechanization at American Radiator and Standard Sanitary Corporation, Baltimore, has resulted in an immediate ⅓ reduction in charging time! Here, in a refurbished foundry, Machine Age speed is accompanied by economy and reliability. A Whiting Yard Crane now unloads scrap metal . . . and Whiting Cupolas, Ladles, Weigh Hoppers and a Gantry Charging Crane team up to produce more, and produce it faster. Practical allocation of manpower helps American-Standard pare its over-all production costs even more!

Learn about the advantages gained when you use foundry equipment designed for your needs. Write for the Booklet, "Whiting Foundry Equipment." Whiting Corporation, 15628 Lathrop Avenue, Harvey, Illinois.

75th Year FEMA COST-SAVING EQUIPMENT...THE WAY TO HIGHER PROFITS

FOUNDRY EQUIPMENT

WHITING

MANUFACTURERS OF CRANES; TRAMBEAM HANDLING SYSTEMS; TRACKMOBILES; FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

Circle No. 188, Page 157-158

dietrich'

What does the man in the shop think about as he goes through his repetition routine? Perhaps—if you have never worked on a production line—you believe he is always thinking about his work. If he did, he'd go stir crazy in a week. From experience and observation I'd like to explain what men think about to relieve the monotony and boredom of repetitive operation.

First, the squeezer molder. His body is trained to go through a series of movements designed to produce an acceptable mold. When he first opens his floor, he must direct these movements with his mind. After the first ten molds, his body falls into the rhythm and gradually increases the tempo until it gets ahead of his mental direction. His floor is outlined with the first ten molds, and his cores are in position. From this point, his mind leaves his body and he begins to think about everything except the mold his trained body is producing.

The squeezer molder is now free to plan his future, settle world affairs, or solve the mystery of the universe. But, does he do these things? No! He thinks, "I must have had a heluva time Saturday. I can't remember where I was. Let's see! Tavern number one. Picked up Charlie. Tavern number two. Mike and Pete got into the act. Tavern number three. How did I get under that table? Somebody must have called Mike a Red Neck again. Tavern number—can't remember leaving number three. Wonder how I got home? Oops! There's the whistle. Time to put on the feed bag." And the squeezer molder takes off on a dead run. He doesn't quit early, but he doesn't work overtime either.

Then there is the visiting engineer. He has a red I.D. tag that allows him to roam in any part of the plant. When we see him, he has a roll of blue prints under one arm, an oversized pipe hanging out of the corner of his mouth, and his shirt sleeves rolled up just below his elbows. He is squatting in the

orner

y h. f. dietrich

gangway watching the endless belt of the new-sand conveyor. You would think that he is planning a new delivery system. But he is not! He has been sitting bent over a drawing board until his neck and back muscles became cramped. The office force objects—with dirty looks and snide remarks—to his pipe. He just had to have a break.

The blue prints are props. If anyone sees him going through the shop, they will think he is on official business. Unless someone unrolls them, no one will know that the prints are the plans for the old parking lot. Because there is always a cool breeze coming through the new-sand shed, and because no one from the office will venture through the foundry unless on urgent business, this gangway is the best place in the world to spend a half hour with a pungent pipe. If someone from the shop sees him, they will think, as you did, that he must be planning a new system.

The last character for whom there is space was Joe the maintenance man in Rockford. He was an expug who was just a little punchy from sparring with Dempsey. Part of his equipment was one of the largest ball-peen hammers I have ever seen. One day, Joe sighted along a conveyor belt and decided that the far side was riding high on the pulley. He loosened the adjustment screw through the moving belt, but the pillow-block stayed frozen in place. A few exploritory taps with the hammer failed to move the block and Joe lost his temper. With a mighty swing, Joe missed the block and drove the hammer, and his arm, under the belt. Like a judo expert the belt flipped Joe over the pulley and onto his back, dislocating his shoulder in the process. I would like to tell you what Joe thought and said, but I learned recently that a cute little blonde at the office edits my copy—and cuts out my punch lines. If I explained Joe's reactions, her ears would turn an unbecoming shade of red, So, I'll leave it to your imagination.

Circle No. 190, Page 157-158

have you read . . . ?

Coated Abrasives. Coated Abrasives Manufacturers' Institute, McGraw-Hill, New York, 1958, 426 pp.

The nature of coated abrasives, their advantages and applications and their efficient methods of use are of primary concern in this text. It tells also how these abrasives are manufactured and how to use them in specific industries; such as, ferrous and non-ferrous metalworking, woodworking, glass, and plastics. Special attention is given to their use in the automotive field.

Wilkinson, W. D. and W. F. Murphy, **Nuclear Reactor Metallurgy**, Van Nostrand, New Jersey, 1958, 382 pp.

This resulted from a training course at Argonne National Laboratory. It is primarily descriptive and qualitative, assumes no previous training in metallurgy. The authors go into phase diagrams, allov theory and crystallography.

Uranium, of course, is the significant metal; so its properties are well discussed. Special problems are covered also where plutonium, thorium, beryllium and zirconium enter the picture.

An important chapter is devoted to nondestructive testing of nuclear reactor components.

Creep and Fracture of Metals and High Temperatures, National Physical Laboratory, 419 pp. 1954 Philosophical Library, New York. $12.

By definition, this work pertains to the creep of metals as a slow continuous deformation when said metals are subjected to stress at high temperature. When metals are so used in engine and boiler operations, in steam and gas turbines as well as in rockets and jets; the right metal is of greatest importance. There has been much development in creep-resistant alloys in recent years. Thus, the need for this volume has come to be; for it reviews methods for controlling the phenomena that determines the strength of these materials at high temperatures.

Howard, E. D. **Modern Foundry Practice.** Philosophical Library, New York (1959). 464 p.

This is a collected work of several authors: A. B. Everest, Arthur Logan, T. Bishop, G. F. Butters, A. Tipped, James Timbrell, F. H. Hoult, *et al.* It is also a guide to British foundry work and serves as a handbook for apprentices, students, craftsmen and executives in the industry. The current edition has added new information about spheroidal-graphite cast iron, pressure-cast aluminum pattern plates, epoxy resin patterns, pop-off flasks and resin-bonded cores. There is a chapter on shell molding and the carbon dioxide process. An appendix in two parts is composed of inspection of castings and foundrywork training.

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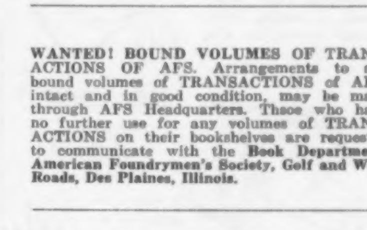

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